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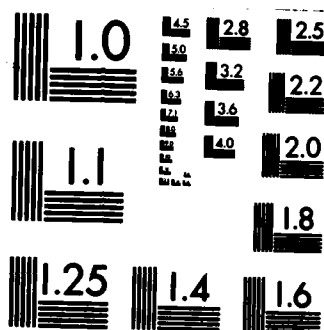
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European Science Notes

US Office of Naval Research, London

Commanding Officer CAPT M.A. Howard, USN
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Editor Larry E. Shaffer

April 1985
Volume 39
Number 4

Behavioral Sciences

- cont to p 4*
Topics summarized include:
- Cognitive Developmental and Individual Differences
More on Neo-Piagetian Research Richard E. Snow 127

Researchers in Greece as well as France and Switzerland continue to examine developmental variations and individual differences in cognitive task performance in the Neo-Piagetian framework. Of particular interest is new evidence on the nature and growth of formal scientific thinking in adolescence and young adulthood. The traditional Piagetian theory of intelligence is further undermined. New theoretical models and new methods of analysis are proposed.

- More on the Cognitive Psychology of
Question-Asking Richard E. Snow 134

Further Swiss work on the function of information-seeking questions extends to the psychology of action planning and control. Much more work is needed on the important but neglected role of question-asking in cognitive processing.

Biological Sciences

- Bioelectrochemistry Course Focuses on
Membrane Phenomena Martin Blank 136

The second advanced course on bioelectrochemistry at the International School of Biophysics concentrated on the following areas: structure and stability of membranes, membrane transport, and energy transduction.

- Medical Oceanography in France Thomas C. Rozzell 139

The Centre d'Études et de Recherches de Biologie et Oceanographie Médicale concentrates on studies of marine hygiene, bacterial pollution of the marine environment, and chemistry and physics of the ocean. This article surveys the center's fundamental and applied research.

- (10 p D)*
Wireless Medical Telemetry in Europe Thomas C. Rozzell 141

The European Community has started a program designed to improve the monitoring of critically ill patients. This article describes the program to introduce monitoring by infrared telemetry.

Computer Sciences

- Heriot-Watt University Develops CAD System for
Autonomous Submersible Vehicle J.F. Blackburn 144

Researchers at Heriot-Watt University, Edinburgh, Scotland, have developed a computer-aided design facility to generate automatic guidance and control strategies for an unmanned, autonomous, submersible vehicle. This article discusses the computer-aided generation of a three-dimensional environment and the interpretation of this environment to generate two-dimensional perspective views and simulated sonar images.

Material Sciences

- Gas Turbine Technology Featured at UK Conferences R.L. Jones 147

The conference Protective Coating Systems for High Temperature Gas Turbine Components included papers on pulsed pressure aluminizing, corrosion resistance, and thermal barrier coatings. The UK-US Navy Workshop on Gas Turbine Materials in a Marine Environment focused on the corrosion of hot turbine blades caused by sea salt and fuel impurities.

- Welding Research at Aachen University Kenneth D. Challenger 149

Aachen University has two institutes for welding research and development. Prozesssteuerung in der Schweisstechnik focuses on problems associated with the applications of robotics to welding. Institut für Schweisstechnische Fertigungsverfahren has many research programs covering most aspects of welding.

- Materials Testing at West Germany's
EHW and MPA Institutes Kenneth D. Challenger 152

The Institute for Ferrous Metallurgy (EHW) at the University of Aachen and the State Institute for Materials Testing (MPA) at the University of Stuttgart are two of the largest organizations in West Germany doing research on the mechanical/fracture properties of structural metals. EHW is involved in all phases of ferrous metallurgy, with emphasis on mechanical/fracture properties, whereas MPA's programs are practically all in materials testing, structural analysis, and materials qualification.

Mathematics

- New INRIA Center Studies Nonlinear Filtering Charles J. Holland 156

A new center of France's Institut National de Recherche en Informatique et en Automatique is doing important fundamental work in nonlinear filtering and smoothing. Solution of these problems will have a high payoff for military and industrial applications in guidance, filtering, and control.

Workshop on Inverse Problems Held in Montpellier, France	Charles J. Holland	158
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The 13th Annual Workshop on Inverse Problems dealt with the applications of inverse problems and inverse scattering problems in quantum mechanics and in nonlinear evolution equations. This article focuses on geophysical applications of inverse problems.

Mechanics

Transonic Unsteady Aerodynamics and its Aeroelastic Applications	K. Isogai	159
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The specialists meeting of the Advisory Group for Aerospace Research and Development's 59th Meeting of the Structures and Materials Panel was held in Toulouse, France, last fall. The papers clearly showed the state of the art of the currently available computational methods for calculating unsteady transonic aerodynamic forces on 2D airfoils and 3D wings.

Physics

Advanced Solid-State Device Research at Siemens: Thyristors and Diode Lasers	Paul Roman	162
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This article reports on pioneering work in two areas--thyristors and high-power diode lasers--pursued in the basic research laboratories of Siemens A.G. in Gerlach, West Germany.

Laser Research at Garching : Some Recent Achievements and Plans	Paul Roman	165
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This article reports on recent developments and plans at the famous Max Planck Institute for Quantum Optics. It describes both laser system development efforts and some noteworthy applications, including plasma physics and laser chemistry.

Space Sciences

Long-Term Space Science Program for ESA	Norman F. Ness	169
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The European Space Agency has proposed a long-term program in space sciences. A major report, *Space Science--Horizon 2000*, calls for projects in solar and heliospheric physics, space plasma physics, planetary science, and astronomy.

News and Notes

The International Adhesion Conference 1984	Guy D. Davis	173
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Behavioral Sciences

COGNITIVE DEVELOPMENTAL AND INDIVIDUAL DIFFERENCES: MORE ON NEO-PIAGETIAN RESEARCH

by Richard E. Snow. Dr. Snow is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1985 from Stanford University, where he is Professor of Education and Psychology.

A previous article reported on the explosion of new styles of theory and research on intellectual development in the Geneva School, following the death of Piaget (see ESN 38-6:295-297 [1984]). Especially noteworthy were the innovative attempts to analyze individual differences in Piagetian task performance and to examine the nature and development of procedural thinking and reasoning in adolescence and young adulthood. This work continues in Geneva, but it is also found in France and Greece. The present article supplements the previous report by bringing this additional work into the picture. It reports a new model of formal thought and new methodological approaches to the problem of analyzing individual and developmental differences in interaction. The results further undermine the traditional Piagetian theory of intelligence.

Research From Greece

Demetriou and Efklides (1979, 1981, in press), of the University of Thessaloniki in Greece, have been revising the Piagetian view of cognitive operations in formal thinking of the sort required in science; they have also begun to bring individual differences in education, gender, socioeconomic status, and rural versus urban culture into the analysis. Piagetian theory posits that formal operational thinking is attained during the adolescent years as an integration of the discrete groupings of classes and relations from the earlier, concrete stage of development. The result of this attainment is a stable equilibrium between assimilative and accommodative processes, making formal thinking the final stage in the development of intelligence. This integration of the formal stage, called by Piaget the *structure d'ensemble*, is free from content restrictions; it operates on

abstractions and on the realm of possibilities in which reality is but one sector. In moving from possible to real worlds, formal thinking includes hypothetico-deductive reasoning. It thus embodies the cognitive operations required for scientific thinking, reasoning, and problem-solving (see Inhelder and Piaget, 1958; Piaget, 1970).

In an early study, Demetriou and Efklides (1979) administered a series of Piagetian tasks chosen to test aspects of reasoning about the ideally possible and the relatively possible in physical systems where action and reaction are involved and where combinatorial and proportional concepts are required. The tasks involved the combination of chemical liquids, conservation of motion in a horizontal plane, and equilibrium in a balance. Subjects represented equal numbers of educated and uneducated male and female adults; educated subjects were chosen from fields other than physical science.

The results showed differences in difficulty among tasks and marked education \times gender interaction; education obviously promotes formal thinking--educated males did better than educated females, but the difference favoring uneducated males over uneducated females was especially large. Also, it was clear that the major aspects of formal thinking could be seen in the performance of young adults. These include the abilities to: transcend reality and operate on the possible; reason hypothetico-deductively; act as experimenter by isolating and controlling variables; and conceive of equivalent inverse and reciprocal relations among opposing and compensatory forces in physical systems, and thus understand proportionality. The strong effects of education and gender argue that the mere accumulation of experience to young adulthood is not sufficient to develop these abilities; individual differences in experience are important.

Most importantly, however, there seemed not to be a unity among these abilities as required in Piagetian theory. Instead, the overall results and the detailed content analyses of task performance undertaken by the authors suggested at least three loosely connected kinds of thinking. One concerns the ability to detach from reality and conceive of possibilities; it appears to derive from extrapolation from everyday physical and social reality rather than from combinatorial thinking and propositional transformations, as Piaget assumed. Another reflects the ability to conceive and conduct experiments--formulating hypotheses, devising experimental

procedures, and inferring from results. A third concerns the abilities involved in seeing the multiple relations that connect the facets of complex physical systems. The data seem to suggest that the second two kinds of ability are only indirectly related; they both appear to be attained through the mediation of the first set of abilities (as a necessary but not a sufficient condition for their attainment). The results, furthermore, argue against Piaget's assumption that combinatorial thinking automatically leads to the unification of inverse thinking and reciprocal thinking in a single system.

Demetriou and Efklides (1981) then review a variety of other evidence calling Piaget's unified theory of formal thought into question, and develop their own conception further. They argue that Piaget's *structure d'ensemble* is an

epistemological ideal of limited value for psychological science and proceed to identify those aspects of formal operational thinking that appear to be empirically verifiable. They start from Flavell's (1963, 1977) view that there is an early strategic level of formal thought marked by the development of several abilities. First, in thinking about a given problem the subject becomes able to proceed from possible to real. Second, the subject begins to operate not only on real entities but also on thought products. Third, the subject's approach to problem-solving starts to take on the character of hypothetico-deductive reasoning. Demetriou and Efklides elaborate the first two of these ability categories as shown in Table 1. They also take issue with Flavell regarding the third ability, arguing from their data that

Table 1

Delineation of Abilities Involved in the Development of Formal Thought (after Demetriou and Efklides, 1981, in press)

- I. The Strategic Level--development of an overall problem-solving orientation.
 - A. Development of thinking that can proceed from the possible to the real, including the ability to:
 1. Detach from the specifics of a problem.
 2. Organize the specifics on a theoretical level.
 - B. Development of the recognition that the specifics of a problem and a theoretical organization of them are different entities, and that problem solution comes from performance on the latter, including the ability to:
 1. Connect logical statements interpositionally.
 2. Grasp the consequences of such propositions with respect to material referents.
 3. Envisage alternative points of view with respect to a problem.
- II. The Tactical Level--development of independent relational, experimental, and correlational-probabilistic spheres of thought.
 - A. Relational sphere--development of the ability to synthesize or reduce two or more problem factors into a single mental product, including the comprehension of:
 1. Qualitative covariations in causal systems.
 2. Quantitative direct covariations (ratios).
 3. Quantitative inverse covariations (proportions).
 4. Simultaneous quantitative coordination of more than four factors or two relations at a time (integrating ratio and proportion in a single system).
 - B. Experimental sphere--development of the ability to analyze or produce the set of all possible relations in which the factors in an initial relation could appear, including the:
 1. Simple production of combinations.
 2. Isolation of variables more or less systematically.
 3. Drawing of inferences (forming hypotheses) from experimental results.
 4. Exhaustive and precise testing of these inferences to formulate valid interpretations.
 - C. Correlational-probabilistic sphere--development of the conception of the probability of events or phenomena and the correlations between such events and phenomena, including the ability to:
 1. Generate the possibilities of events through hypothetico-deductive reasoning in relation to the set of possibilities to which the event belongs.
 2. Formulate mathematical expressions for the degree and direction of probability or the covariation of the relations produced.

hypothetico-deductive reasoning is not yet in evidence in this early strategic level; subjects here are not yet able to deduce from their conceptions, or to plan and execute alternative procedures for testing them.

With this strategic level in place, the various Piagetian formal operations are subsequently acquired independently at the level of tactics. The tactics are what Demetriou and Efklides refer to as "spheres" of formal thought within a level. They would agree with Piaget (and many others) that the developing individual's interaction with the physical and social environment produces an overall problem-solving orientation--the strategic level. But beyond this general, experiential product there are various special realms of experience--at the tactical level--with their own structures and special demands, that produce the development of differentiated, crystallized abilities independently suited to performance with respect to these special environmental demands. Table 1 shows three such spheres of formal thought at the tactical level, which are called the relational, experimental, and correlational-probabilistic spheres. Also given are the detailed abilities identified with each. The order of spheres and constituent abilities shown depicts their hypothesized order of development, i.e., the order of their simplest manifestations during psychological growth. It is further posited that the relational and experimental spheres develop relatively independently; the developmental relations among abilities within a sphere should be robust, whereas intersphere ability relations should be relatively loose. Also, the fusion of abilities in these two spheres ultimately produces the third, correlational-probabilistic sphere.

The evidence that Demetriou and Efklides amass supports their elaborated model. The strategic versus tactical distinction is supported by three sources of evidence. First, performance that is characteristic of formal thought in fact often appears earlier, at the concrete operational level: young children generate theories of the problems faced, though they are admittedly rigid and closely connected to the phenomenal aspect of such problems; they also accept a lack of closure regarding the information given and recognize that they must search for alternative sources of information. Second, illiterate adults appear able to deal with formal problems, at least as ideal possibilities, and to suggest and operate mentally upon theories of the problem; they

might not, however, be able to recognize or plan tests of their theories. Third, even sophisticated adults can fail to handle some classical formal problems. Hypothesizing a strategic level of development occurring before the completion of Piaget's concrete stage and extending into the early formal stage seems to account for these variations. The strategic level provides a necessary but not a sufficient condition for formal thought. It appears further to be more a function of learning through diversifying experience and transfer relations among problem types in a complex environment, and of formal educational training, than of age itself.

There is also evidence for the differentiation of tactics--the spheres of thought that are the constituents of Piaget's *structure d'ensemble* and that constitute the set of formal abilities underlying all Western experimental sciences. The Demetriou-Efklides (1981) review notes several studies that indicate developmental differentiation between the experimental and correlational-probabilistic spheres. Their own results show that even in adulthood relational and experimental abilities appear distinct. Compartmentalization between the spheres is also suggested by evidence showing lack of training transfer among Piagetian tasks presumed to reflect different spheres. Even the studies that show high correlation among tasks representing different spheres, and thus suggest homogeneity of formal thinking, nonetheless also show that intrasphere correlations are typically higher, whereas intersphere correlations are typically lower, than a strictly homogeneous model would predict. Some degree of correlation should be expected if all spheres at the tactical level are differentiations from a common strategic level. And it is noted that most prior studies used samples of educated adolescents and college students; the full range of adult intelligence has been rarely studied.

The new research reported by Demetriou and Efklides (in press) adds more evidence supporting the differentiated model. A sample of 400 subjects was collected to represent four age groups; 9th-graders (average age 14.5); 12th-graders (average age 17.5); college students (average age 20.9); and middle-aged adults (average age 44.8). The high school subjects also reflected three socio-economic-cultural groups: rural-agricultural, urban-working class, and urban-professional. All groups could also be subdivided into males and females. Their performance on a wide range of tasks, representing relational

and experimental spheres, several developmental steps within each, and also strategic-metacognitive abilities, was then analyzed (correlational-probabilistic tasks were not included in this study).

Oblique factor analysis was used to show separate experimental, relational, and strategic ability factors, as predicted. The first two factors were somewhat correlated ($r = .40$). The third was interpreted as "the capacity to conceive of possibilities and reflect upon them"; it seemed to reflect part but not all of what is hypothesized as strategic level ability. Similar factor structures were obtained in the overall sample and in various subsamples. Both raw scores and factor score methods were then used to examine the hypothesized developmental sequences. The intrasphere and intersphere task relations were generally found to follow predictions; the developmental sequences within the relational and experimental spheres, as shown in Table 1, thus appear to be valid.

Figure 1 gives the overall factor-score trends for the four age groups, separately for males and females. For the 9th- and 12th-graders, only the means for the high socio-economic level

students are shown, as these seem to be the most comparable to the college student and middle-ager samples; the middle-agers are teachers. Means for the rural-agricultural high school samples were substantially lower than the means depicted in Figure 1; means for the urban-working class high school samples were typically intermediate. The developmental (cross-sectional) trends for the relational and experimental abilities show gradual increases to college and decline to middle age. There appear to be marked gender differences favoring males for the relational abilities throughout the age range. For the experimental abilities, the gender difference is seen in the high school years but disappears thereafter. The strategic ability trend is more erratic, declining from its 9th-grade high to 12th-grade, but increasing to college before declining again to middle age. The gender difference in this ability appears substantial only at college age.

The most important results, however, cannot be pictured in Figure 1, for they concern the qualitative developmental relations apparent within and between spheres and levels. In addition to supporting the validity of the

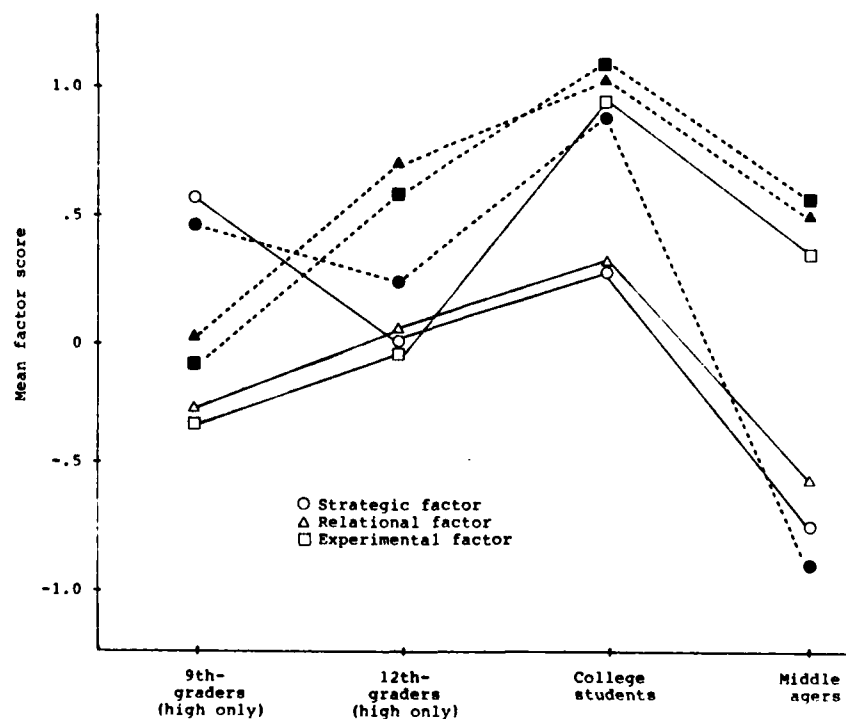


Figure 1. Mean factor scores for strategic relational and experimental factors for males (shaded symbols) and females (unshaded symbols) in four age groups. (High school data are for students of relatively high socio-economic level only.)

intrasphere sequences shown in Table 1, they suggest that different ability-development models are needed within spheres as opposed to between spheres. To paraphrase Demetriou and Efklides (in press), the capacity to conceive of and reflect upon possibilities (part of the strategic level) appears to evolve from a basic ability to draw conclusions from ready-made premises, through an ability to produce the premises, to a postformal ability to build complementary or competing systems of premises and conclusions, and to reflect on one's own thought processes about these. This strategic aspect of cognition continues to develop after the emergence of the tactical level abilities. Strategic abilities are not displaced by tactical abilities, but instead continue to exert influence in the development of the domain-specific abilities. A modification model best characterizes the emergence of tactical abilities from the strategic abilities; the preceding abilities are transformed and refined by differentiation to match the special demands of the everyday situations faced (e.g., educational tasks) and thus consolidate as functionally distinct abilities.

The experimental sphere evolves from the mechanistic production of combinations, and from the synchronous, simple ability to isolate variables, to the ability to connect different data and form working hypotheses to be tested exhaustively. The relational sphere begins as the ability to conceive of qualitative covariation, develops to the ability to handle ratios, then proportions quantitatively, and then to an integration of the two. Once these two spheres emerge from the strategic level, a modification-and-inclusion model best fits the development of abilities within each--i.e., Ability X_1 is modified to produce Ability X_2 , and both become included in a further ability that integrates them. A mediation model, however, best represents intersphere developmental relations--i.e., a preceding Ability X_1 from one sphere facilitates or mediates the development of a subsequent Ability Y_2 in a different sphere, but X_1 does not become a part of Y_2 nor do the two become integrated in a third ability. By positing qualitatively different abilities at different developmental stages and qualitatively different processes underlying progress across stages, the Demetriou-Efklides theory differs sharply from the Piagetian notion that the same processes underlie all development.

There remains, of course, the need to demonstrate these different processes

in longitudinal studies. But another problem in either longitudinal or cross-sectional research concerns the methodology for testing hypotheses about the staging of developmental relations between tasks. Demetriou and Efklides (in press) used a method proposed by Froman and Hubert (1980) for comparing the contingency table for any pair of tasks with what would be expected if the tasks were independent. An example is provided in Table 2 based on data from Demetriou and Efklides.

A staging hypothesis that Ability X_1 leads to Ability X_2 in the same sphere (a modification-inclusion model) should show a pattern such as that shown in the upper panel of Table 2. Few persons should pass items reflecting a higher stage of development on Ability X_2 than they do on Ability X_1 . The underlined frequencies show the error cells; with perfect measurement and a valid hypothesis, those cells should be empty. A case of synchronous development of two abilities should produce high frequencies mainly in the main diagonal with low or zero frequencies both above and below it. On the other hand, a hypothesis that Ability X_1 leads to Ability Y_2 in a different sphere (a mediation model), such as that shown in the lower panel of Table 2, should show higher frequencies in the error cells than in

Table 2

Bivariate Frequency Distributions for Abilities X_1 and X_2 From the Same Sphere and X_1 and Y_2 From Different Spheres (based on data from Demetriou and Efklides, in press)

		Ability X_2			
Ability X_1	Stage	a	b	c	d
Stage	a	85	4	2	0
	b	53	<u>23</u>	<u>4</u>	<u>0</u>
	c	57	35	14	8
	d	28	41	39	<u>7</u>
		Ability Y_2			
Ability X_1	Stage	a	b	c	d
Stage	a	7	63	8	13
	b	15	<u>44</u>	<u>5</u>	<u>16</u>
	c	6	68	14	<u>26</u>
	d	4	56	15	<u>40</u>

the previous cases, but it is not clear just what pattern should be the criterion expectation in this case.

Research From France and Switzerland

For the purposes of the Demetriou-Efklides study, the method used seems to have worked satisfactorily. But their work relates to the more general problem of integrating differential and developmental methods in the study of intra-individual and inter-individual differences in development now also being faced by researchers in France and Switzerland. This research also undermines the Piagetian notion of unidimensional development of *structure d'ensemble*.

The Piagetian model expects that abilities emerging at the same stage will be synchronous and that the order of ability development across stages will be invariant, showing a hierarchy of the form depicted in Table 2 (upper panel). Data showing patterns more like Table 2 (lower panel), especially if the two abilities are supposed theoretically to be synchronous, disconfirm the Piagetian model. To explain the occurrence of such patterns, Piaget invoked the notion of *horizontal decalage*; disturbances in synchronism due to resistances that situational aspects of the measurement tasks might offer to the subject's performance. Unfortunately, free use of this notion to explain lack of correlation in such instances renders Piagetian theory unfalsifiable and thus not scientifically useful. It is the case, however, that horizontal decalages cannot produce all possible forms of asynchronism; rather, they imply certain hierarchical relations between ability acquisitions. Situational resistance in one task (e.g., that associated with the ability labeled X_2 in Table 2, upper panel) and not in another (e.g., that labeled X_1 in Table 2) implies that subjects could pass both, or fail both, or pass X_1 while failing X_2 ; but they should not pass X_2 while failing X_1 . In other words, the pattern of data in Table 2 (upper panel) should occur. Thus, this pattern can result from the within-sphere ability sequence hypothesis of Demetriou and Efklides (in press) or the horizontal decalage hypothesis of Piaget. They are difficult to distinguish using the Demetriou-Efklides approach.

Longeot (1969, 1978, 1983) and Lautrey (1980) in France, and De Ribaupierre and Rieben (1983) in Switzerland have been developing new approaches to the range of problems in this area. A collaboration among Lautrey, De Ribaupierre, and Rieben (in press) now

provides an especially useful summary and demonstration in English.

Lautrey, De Ribaupierre, and Rieben (in press) used data from an extensive study of individual differences in Piagetian tasks to attack several methodological problems. Subjects were 154 children ranging in age from 6 to 12 years. They performed two logico-mathematical (LM) tasks and six infra-logical (IL) tasks to provide the data. According to Piagetian theory, LM and IL tasks reflect the same underlying formal cognitive function that develops from a common process; they differ only in that LM tasks deal with the relations of resemblance and difference between discrete objects, whereas IL tasks deal with continuous properties and relations of proximity between parts of the same object. They should present a strictly synchronous development. Piagetian analysis of the tasks suggests that, if there is a decalage, LM ability should develop in advance of IL ability; IL in advance of LM would be difficult to interpret in Piagetian terms.

Aside from perfect synchrony, three kinds of decalage are logically possible: homogeneous collective decalage, in which subjects maintain the same rank order on LM and IL tasks but performance on one kind of task (e.g., IL) is systematically depressed by situational resistance; individual decalage, in which subjects change their rank order on LM and IL tasks but maintain the same average performance; and heterogeneous collective decalage, in which subjects change their rank order and also display depressed performance on one task because of situational resistance. Only the occurrence of individual decalage disproves the hypothesized univocal relation between LM and IL tasks, because situational resistance cannot be imagined to retard the performance of one subject and facilitate that of another. Heterogeneous collective decalage could occur despite true univocal relation between LM and IL tasks, if situational resistance had differential intensity for different subjects. The methodological problem then is to test for the presence of individual decalage.

A three-step procedure is advocated. First, an intra-task hierarchy must be verified for each task. Longeot's (1969) method is used for this step; one forms a ratio between the number of inversions between passes and failures relative to the expected order and the number of expected inversions if patterns of responses were randomly distributed. The method has the advantage that all items need not be scalable;

hierarchy can be detected among groups of items, even if items are not hierarchically ordered within groups. Second, given intra-task hierarchy, simple application of Kendall's Tau coefficient will show the degree to which subjects are ordered similarly on any pair of tasks. High coefficients suggest the presence of either synchrony or homogeneous collective decalage. Low coefficients imply the presence of individual decalage or heterogeneous collective decalage. Third, the two possible causes of low Tau coefficients can be distinguished by determining whether the errors with respect to the conjoint hierarchy are symmetrical. The recommended procedure weights errors according to their seriousness for the hypothesized synchrony under test, and uses a method for evaluating the importance of errors for specific predictions without requiring that the prediction apply to the total contingency table. The method was originally developed by Hildebrand, Laing, and Rosenthal (1977a, 1977b) for use with ordinal data (it is not detailed here since it is publicly available).

Applying this procedure, it is shown that the hypothesis of individual decalage--i.e., reversals of subject order without evidence of situational resistance--cannot be rejected in at least the case of the tasks studied by Lautrey, De Ribaupierre, and Rieben (in press). The implication is that different paths of development may be possible for different subjects. As before, it is clear that longitudinal studies are needed to demonstrate these different paths.

The method advocated by Lautrey, De Ribaupierre, and Rieben (in press) could of course be applied to the data of Demetriou and Efklides (in press). Table 2, and others like it, could well display one or another of the types of decalage delineated above, or synchrony. In particular, the example of Table 2 (upper panel) could, in French-Swiss terms, be interpreted as either heterogeneous collective decalage or individual decalage within one ability; in Greek terms, it exemplifies sequential hierarchy between two abilities. It seems clear that the French-Swiss and Greek teams should collaborate, but they do not know one another's work.

There is a further complication. Longeot (1983) has been studying the same problem--intra- and inter-individual differences in Piagetian task performance during the formal stage of intellectual development. He finds inter-individual differences within

intra-individual differences that he interprets as reflecting cognitive style. The tasks studied are identical in form, but they differ in apparently trivial content (according to Piaget). Yet individuals can display either "procedures of realization" or "procedures of formalization" in their performance. They also display preferences for "taxonomic classes" or "thematic classes." It appears that there are both intra-individual differences over time and tasks, and inter-individual differences over time and tasks, that can be interpreted as preferences for certain contents, procedures, and classifications--or more generally as differences in sensitivity of functioning to differences in content of a task, given the same form of a task. The patterns displayed in contingency tables such as those studied by Demetriou and Efklides and by Lautrey, De Ribaupierre, and Rieben could well be interpreted in Longeot's terms. Despite the good work of all these people, there is still a methodological, and thus a theoretical, problem.

References

- Demetriou, A., and A. Efklides, "Formal Operational Thinking in Young Adults as a Function of Education and Sex," *International Journal of Psychology*, 14 (1979), 241-253.
- _____, "The Structure of Formal Operations: The Ideal of the Whole and the Reality of the Parts, in *Social Development in Youth: Structure and Content*, ed. J.A. Meacham and N.R. Santilli (Basel: S. Karger, 1981).
- _____, "Structure and Sequence of Formal and Postformal Thought: General Patterns and Individual Differences," *Child Development*, in press.
- De Ribaupierre, A., and L. Rieben, "Aspects Différentiels du Fonctionnement Cognitif: Procédures, Décalages, et Dysharmonies," *Archives De Psychologie*, 51 (1983), 9-16.
- Flavell, J.H., *The Developmental Psychology of Jean Piaget* (Princeton, NJ: Van Nostrand, 1963).
- _____, *Cognitive Development* (Englewood Cliffs, NJ: Prentice-Hall, 1977).
- Froman, T., and L.J. Hubert, "Application of Prediction Analysis to Developmental Priority," *Psychological Bulletin*, 87 (1980), 136-146.
- Hildebrand, D.K., J.D. Laing, and H. Rosenthal, *Analysis of Ordinal Data*, Sage University Series on Quantitative Applications in the Social Sciences, Series No. 07-008 (Beverly Hills: Sage Publications, 1977a).

- _____, *Prediction Analysis of Cross Classifications* (New York: Wiley, 1977b).
- Inhelder, B., and J. Piaget, *The Growth of Logical Thinking From Childhood to Adolescence* (New York: Basic Books, 1958).
- Lautrey, J., "La Variabilité Intra-Individuelle du Niveau de Développement Opératoire et ses Implications Théoriques" (Manuscript submitted for publication, 1980).
- Lautrey, J., A. De Ribaupierre, and L. Rieben, "Intra-individual Variability in the Development of Concrete Operations," *Genetic Psychology Monographs*, in press.
- Longot, F., *Psychologie Différentielle et Théorie Opératoire* (Paris: Dunod, 1969).
- _____, *Les Stades Opératoires de Piaget et les Facteurs de l'Intelligence* (Grenoble: Presses Universitaires de Grenoble, 1978).
- _____, "Interindividual Differences of Functioning in Intellectual Operations" (Paper presented to the International Society for the Study of Behavioural Development, Munich, 1983).
- Piaget, J., "Piaget's Theory," in *Car-michael's Manual of Child Psychology*, Vol 1, ed. P.H. Mussen (New York: Wiley, 1970).

1/17/85

MORE ON THE COGNITIVE PSYCHOLOGY OF QUESTION-ASKING

by Richard E. Snow.

A previous article (ESN 38-7:352-356 [1984]) reported the work of Flammer in Switzerland on the nature of question-asking. Since information-seeking questions have important functions in many facets of everyday life, and since these functions have been relatively neglected in cognitive and instructional psychological research, it is worth reporting on Flammer's further work along this line.

Two new experiments are now in hand (see Flammer, Grob, Leuthardt, and Lüthi, 1984) that investigated the function of questions in the context of planning and carrying out complex action sequences. The action sequence chosen for study needed to be one with formal structural characteristics similar to a variety of other procedural domains, but one in which the subjects, who were college students, could be expected to

differ naturally in relevant prior experience. Thus, the chosen domain was cooking; the particular action sequence called for preparing a "mousse au chocolat" according to a special recipe following standardized and rather simple instructions. All questions were to be asked and answered prior to starting the procedure. The procedure was then carried out, with experimenter intervention only in extremely incorrect cases (since the subject and experimenter had to eat the final product!).

The action sequence consisted of a complex hierarchy of 12 constituent actions (called subactions) that could be described according to five aspects: goal, stop-rule, operation, instruments, and ingredients. It was assumed that cooking knowledge consisted of knowledge about several of the subactions or steps and one or more of their aspects, and about two possible types of subaction relations (Step X presupposes Step Y is finished; Steps X and Y may be executed in parallel). It was further assumed that some aspects of an action could be inferred (with more or less confidence) from other aspects of that action and that subjects would not necessarily seek to determine all aspects of an action before executing it.

Experiment I had three purposes. It was important, first, to test the usability of the assumed procedural knowledge organization. A second purpose was to compare results from this sort of action-planning situation with those reported by Miyake and Norman (1979). That study had compared easy and difficult versions of an instructional manual, using college students who were either beginners or partly knowledgeable in the topic presented. The number of questions produced after reading was higher for knowledgeable subjects in the difficult condition than in the easy condition, but the reverse was found for beginners. This result suggests that some intermediate amount of discrepancy between prior knowledge and task demand generates the most questions; the relation between questions asked and amount of prior knowledge should thus be an inverted U-function, given constant task demand. The extremes of such a curve would show that one can know too much or not enough to ask a question, as Miyake and Norman (1979) had predicted, and found.

A third aim was to examine whether subjects with different degrees of prior knowledge would ask different kinds of questions. From Flammer's prior research, it was expected that subjects with more previous general knowledge would show:

1. More questions about subaction goals, because familiar actions tend to be accessed merely by mentioning their goals;
2. More questions about stop-rules, because these are recognized in advance as important for intermediate decision making--beginners are more concerned about where to start than where to stop;
3. Fewer questions about operations, since these are more easily inferred especially given knowledge of the goal;
4. Fewer questions about instruments, because of more experience with cooking utensils;
5. More questions about sequencing of subactions, because the knowledgeable subjects could attend to organization given more familiarity with the subactions--beginners would be too overwhelmed with learning subactions to attend to overall organization;
6. More inconsistency questions since knowledgeable subjects would be more likely to detect inconsistencies;
7. More yes/no questions, because these are often sufficient given more prior knowledge.

Experiment II followed the same procedure with a new sample of college subjects drawn from the same institutions. Here, however, subjects were led to expect either a generally easy and riskless recipe or a generally difficult and risky recipe. The manipulation was designed to vary confidence in information held, since previous work had shown this to be an important factor in question-asking. More questions were expected in the difficult condition than in the easy condition, particularly in the stop rule and organization categories; the difficult condition should also lead subjects to rely less on mere goal information and more on operation and instrument questions in order to increase confidence.

Results for total number of questions asked are shown in Figure 1. In Experiment I and in the difficult condition of Experiment II, the trend vaguely suggested an inverted U-function. But this curvilinear component was not significant; in all three data sets, the linear trend was significant--more prior knowledge produced fewer questions. Furthermore, the easy versus difficult contrast showed some differences, but again these were nonsignificant. The differences between the Flammer results and the Miyake-Norman results suggest the importance of careful calibration of prior-knowledge measures and also the possible sensitivity

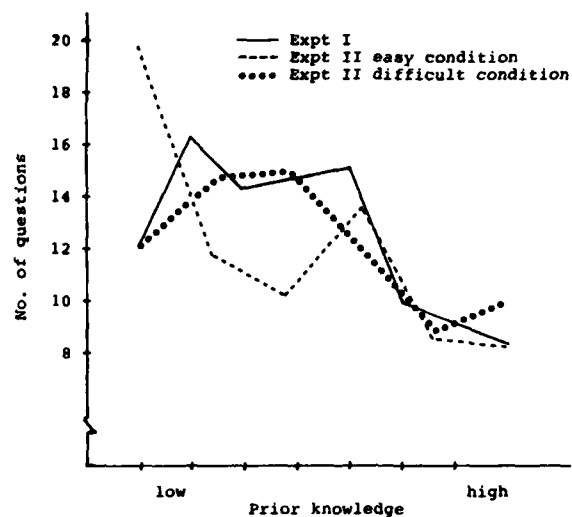


Figure 1. Results for Experiments I and II, showing relations between total number of questions asked and levels of prior knowledge.

of effects to interactions with experimental conditions. Flammer notes a possible floor effect; his subjects may all have had enough prior experience with cooking to attenuate variance at the low end of the prior-knowledge scale. Also, subjects' questions were answered in the Flammer experiments--so knowledge accumulated to influence further questions--but they were not answered in the Miyake-Norman experiment. Further research on questioning will need to attend to these issues.

Regarding qualitative question categories, predictions 1, 2, 3, 4, and 5 for Experiment I above were supported. There were too few inconsistency questions to test that contrast, and the many yes/no questions did not vary with prior knowledge. In Experiment II, predictions were confirmed for the stop-rule category; they were in the predicted direction for organization, operation, and yes/no questions, though not significant. Frequencies for goal and instrument questions were nonsignificantly reversed from prediction. Also, it was not clear that the manipulation of expectancy for an easy versus difficult task was strong enough to have influence.

There are several implications for further research from these results and from some detailed analyses of ratios of different kinds of questions over levels of prior knowledge. One is that the general decline in number of questions over levels of prior knowledge masks a relation between organization (i.e.,

higher-order) questions and detail (i.e., lower-order) questions. The frequency of organization questions remained relatively constant over levels of prior knowledge, whereas the frequency of detail questions declined. Perhaps less experienced subjects asked organization questions, but only after they had accumulated enough detailed knowledge to be able to do so.

Another implication fits with prior theories positing that complex actions are hierarchically organized, with conscious control functions toward the upper end and more automatized functions toward the lower end of the hierarchy. Thus, operations are more readily automatized, whereas goals remain longest under conscious control. Knowledgeable subjects communicate about well-known actions by referencing only their goals, and think about those actions by activating goal representations. Also, operation and instrument questions decreased with prior knowledge either because the information was already known or was easily inferred after goal and stop-rule questions had been answered.

The Flammer work suggests a new format for developing links between research on question-asking, knowledge organization, and action planning and control. Question-asking, as an action planning device particularly, deserves much more attention in cognitive psychology than it has received to date.

References

- Flammer, A., A. Grob, T. Leuthardt, and R. Lüthi, "Asking How to Act," *Archives de Psychologie*, 52 (1984), 103-120.
- Miyake, N., and D. Norman, "To Ask a Question, One Must Know Enough To Know What is not Known," *Journal of Verbal Learning and Verbal Behavior*, 18 (1979), 357-364.

1/21/85

Biological Sciences

BIOELECTROCHEMISTRY COURSE FOCUSES ON MEMBRANE PHENOMENA

by Martin Blank. Dr. Blank is Scientific Officer for Cellular Biophysics, Office of Naval Research, Arlington, Virginia.

The second advanced course on bioelectrochemistry of the International School of Biophysics took place at the Ettore Majorana Center for Scientific Culture in Erice, Italy, from 5 through 15 November 1984. G. Milazzo (President, Bioelectrochemical Society, Rome) and I organized the meeting, which was on the electrochemical aspects of ion transport, energy transduction, and signal conduction. In addition, there were discussions on three applications of bioelectrochemistry, the effects of applied electric fields on membranes, mediated and nonmediated transport of pharmacologic agents, and the exploitation of information about biological membranes in the development of industrial processes.

The 64 participants came from many scientific disciplines, including microbiology, physiology, biochemistry, biophysics, botany and physical chemistry, and the discussions reflected this. Of the 18 nationalities represented, one third of the participants were from Italy; the rest were from other European countries, including three Eastern bloc nations as well as North America and Asia.

Structure and Stability Membranes

The first major subject considered was the structure and stability of membranes. I.R. Miller's (Weizmann Institute, Rehovot, Israel) lecture on membrane models focused on two systems: the unusual bipolar lipids of archaebacteria membranes, and the cerebroside commonly found among brain lipids. The lipids of archaebacteria contain cyclopentyl groups that keep the chains fluid, and the cerebroside contains glucose and amide linkages that cause large hysteresis effects. The locking of the lipid molecules into unstable conformations during nerve activity, because of changes in the electric field across the membrane, could cause changes in cerebroside associated with memory. Miller also spoke about the physical aspects of ion transport through lipid bilayers--i.e., the energetics of pore formation--and the effects of charges at membrane surfaces on membrane structure--e.g., a loss of planarity, electrostrictive effects, and dielectric breakdown.

The second lecture on membrane models, by D. Chapman (Royal Free Hospital, London), presented several physical techniques for studying protein-lipid interactions and molecular movements in membranes--e.g. spin labels, fluorescent probes, nuclear magnetic resonance (NMR) studies, and recent infrared techniques using microprocessors to correct for the

water signal. He stressed the importance of using several techniques, since the results of any one technique are not always clear. Two practical problems discussed were: (1) the protection trehalose provides against membrane damage during dehydration, and (2) the formation of stable liposomes by using diacetylenic phospholipids and polymerizing them once the membrane structures are formed.

Moving on to real membranes, J. de Gier (State University Utrecht, The Netherlands) discussed the different classes of amphipathic membrane lipids, and the relations between molecular properties (e.g., polar groups, chain length, the number of double bonds) and membrane properties (e.g., permeability, phase transition temperature). The mechanism of pore formation (diameters about 8 angstroms) in continuous lipid phases at the transition temperature is quite well characterized from transport studies and the enhanced transfer of lipids between the two layers of a bilayer (flip-flop). Certain molecules (e.g., lysolecithin and membrane protein) cause an increase in permeability by the formation of defect regions. However, glycophorin, a major red cell protein, forms a good "seal" with membrane lipids because of hydrophobic amino acids. Inverted micelles in the lipid structures that show up in electron microscope freeze-fracture patterns result in the enhanced transport of the contents of the inverted phase.

The other major component of natural membranes, protein, exists in many different forms--e.g., enzymes, receptors, ion channels, and energy transducing complexes as well as structural elements. G. Lenaz (University of Bologna, Italy) introduced this broad topic, along with examples of increasing complexity to set the stage for the discussion of transport, energy transduction, and electrical excitation. The first example, gramicidin, is a polypeptide that forms an ion channel as a result of head-to-head dimerization. Bacteriorhodopsin, a single chain of about 25 kilodaltons with seven helical portions, forms a natural channel that crosses the membrane to form a polar pore that conducts protons in the presence of light. The much more elaborate mitochondrial complex that includes a channel and a phosphorylase is still not adequately characterized. The times involved in electron transport processes are small compared to the times required by protein molecules to make physical contacts as a result of diffusion, but ubiquinone can diffuse fast enough to accomplish this function in mitochondria.

Membrane Transport

E. Neumann (University of Bielefeld, West Germany) lectured on ionic reactions at membrane surfaces--i.e., the electrochemistry of electric fields applied to membranes, in particular to membrane proteins. The enzymes, receptors, transport proteins, and channels within the membrane matrix or at the membrane surfaces contain charges and dipoles that affect diffusion and reaction rates. Neumann's analysis of the binding of a quaternary nitrogen-containing group to a membrane acetylcholine esterase is useful for predicting the changes in binding to the receptor protein (AChR) due to changes in the physical properties of the AChR molecule as well as the conductance change.

H. Berg (Academy of Sciences of the German Democratic Republic, Jena) dealt with membrane breakdown and fusion brought about by electric fields. Relatively low-intensity electric fields cause the migration and orientation of cells and the formation of "pearl chains"--i.e., rows of cells that are in contact with each other. When the cells are touching, a high-intensity, short-duration pulse can cause the fusion of cell membranes. The high-intensity field ruptures the membrane, but the short duration allows the membrane to reform and the two membranes to fuse. Many different cells have been formed by this process--for example, about 500 erythrocytes have been fused into a single cell. Various combinations of gametes (e.g., oocytes) and of hybridomas (i.e., an antibody-producing cell with a cancer cell) have been reported. Macro-techniques use many cells simultaneously, while micro-techniques use needle electrodes in two cells to control the process.

S.R. Caplan (Weizmann Institute, Rehovot, Israel) lectured on the non-equilibrium thermodynamics of transport. Using the definition of the dissipation function in terms of the flows and driving forces in a system, it is possible not only to delineate the experimental variables that must be measured in order to characterize transport in epithelia, but also to analyze the results of isotope experiments. Caplan gave one example in which the improper analysis of tracer flux data led to erroneous conclusions. The last topic covered was coupling mechanisms and the definition of efficiency. Nonequilibrium thermodynamics offers a useful formalism for the analysis of transport processes and the definition of the components of a system. However, as systems become more complicated, ambiguities can arise, and the discussion at the end of the

presentation dealt with a system in which there was a disagreement about whether the equations adequately described the experimental system.

P. Läuger (University of Konstanz, West Germany) spoke about mediated and nonmediated ion transport through lipid bilayers--the differences between a carrier and a channel. Valinomycin is a carrier of K^+ ions because the ion interacts with the polar core of the molecules, and the hydrophobic exterior can dissolve in the membrane lipids. There is an upper limit of about 10^5 ions per second transported because of the need for the whole complex to move through the membrane lipid. The inner core of the channel forming gramicidin is also polar, but two gramicidins join to form a continuous polar pathway between the two aqueous phases. The rate of flow through this channel is in the range of 10^8 ions per second. Analysis of the fluctuations in conductance provides information about these systems.

The final talk on the subject of ion transport was given by S. Passarella (University of Bari, Italy), who had some interesting results on the effects of laser radiation. Applying laser irradiation of 5 J/cm^2 to mitochondria has no apparent effect on osmotic or enzymatic properties, but there is a clear increase in ATP production that is inhibited by antimycin. Although the mechanism is unknown, during the discussion it was suggested that the irradiation is probably having its effect by converting NADH to NAD^+ .

Energy Transduction

The next major topic, energy transduction, was introduced by D.F. Wilson (University of Pennsylvania, Philadelphia), who spoke about mitochondrial oxidative phosphorylation. The respiratory rate--i.e., the reaction with oxygen--is regulated by three factors: $NADH/NAD^+$, ATP/ADP , and the pO_2 . Mitochondria function as tissue oxygen sensors and control the reflexes that help adjust blood flow (e.g., in the coronary artery).

B.A. Melandri (University of Bologna, Italy) then discussed the biochemistry of chemiosmosis. Mitchell's hypothesis about the alternation of directed proton and electron transporting reactions in mitochondria was presented along with a discussion of the reactions during photosynthesis. The protonmotive force, composed of differences in chemical potential of the protons and differences of electrical potential, plays an important role in phosphorylation. However, the quantitative aspects are not clear. The experimental evidence depends

upon indirect measurements (e.g., dye distribution, electrochromism, fluorescence). Also, measurements are made over relatively large regions, while the relevant processes occur in microscopic domains.

The third lecture in this group, by P. Gräber (Technical University of Berlin), focused on primary charge separation and energy transduction in chloroplasts. He reviewed the components and reactions at the two reaction centers in photosynthesis, and carefully correlated the structure with the components of thylakoids, their redox potentials, and the kinetics of their reactions. Ingenious light gradient experiments leading to the generation of electrochemical potential gradients in thylakoid suspensions, enabled the direct measurement of the charge separation and the determination of rate constants in the nanosecond range. A recently identified protein couples the charge separation across the ion channel to the enzyme.

Electric Signals and Membranes

The next major topic was the effect of electric signals on membranes. I first summarized nerve excitation on both cellular and molecular levels, and then considered nerve membranes and ion channels from an electrochemical point of view. When the properties of charged surfaces (i.e., surface concentrations, surface potentials and surface capacitances) are used to describe ion transport in an excitable membrane containing voltage-gated channels, one can explain the currents during a voltage clamp. It is also possible to show that the gating current conductance determines the ionic specificity of the channel, and that changes in surface charge density brought about by gating currents can cause the opening and closing of oligomeric channels.

F. Conti (National Research Council, Camogli, Italy) presented the different lines of evidence (i.e., using neurotoxins, membrane noise analysis, measurements of gating currents and patch clamping) that support the discrete nature of the permeability changes in excitable membranes. The numbers of channels differ in different nerves, but the single channel conductance appears to be characteristic for each type of channel. The behavior of the channel as a function of voltage, temperature, and pressure shows a decrease in entropy of about 20,000 and an increase in volume of about 40 cubic angstroms when a channel opens. The decrease in entropy coupled with an increase in volume is unusual and may refer to processes like the freezing of 10-15 water molecules.

Round Tables

R. Korenstein (Weizmann Institute, Rehovot, Israel) chaired the round table on mechanistic and kinetic aspects in the interaction of external electric fields with vesicular membranes and integral membrane proteins. The low magnitude of the induced electric field internally can account for the experiments on dielectric breakdown and piezoelectric effects, but it is difficult to explain the stimulation of cell growth and repair. The biological effects may result from the secretion of growth factors, hormones, second messengers, etc., but the mechanisms are unknown. Conti discussed some of the effects of high voltages on nerve axon membranes, and Berg showed an inverse relation between vesicle diameter and the electric field strength required for fusion. C. Harris (University College of Wales, Aberystwyth, UK) presented some new data on dielectric dispersion indicating more rapid diffusion ($D = 10^{-7} \text{ cm}^2/\text{s}$) of proteins in membranes than has been reported, and I showed similar data for proteins in newly formed nerve membranes. M. Markov (Sofia University, Sofia, Bulgaria) indicated that low magnetic fields can affect cell membranes, and M. Grattarola (University of Genoa, Italy) suggested that bone healing is due to the modification of surface receptors by microelectrophoresis or aggregation.

The round table on mediated and nonmediated transport through biomembranes of materials of pharmacological interest was chaired by M. Metzner (University of Tübingen, West Germany), who opened the session with a review of the many transport mechanisms (e.g., passive, facilitated, active, pinocytosis) found in cells. Some algae can enrich Cr and Mn by factors of 10^{11} over the external concentration, and many mechanisms discriminate between d and l forms of molecules. M. Salmona (Institute of Pharmacological Research "Mario Negri," Milan, Italy) described the factors that control the concentration of a drug at different sites in the body. Differences in absorption, perfusion, partition, and diffusion in tissues as well as the possibility of extra barriers in diseased states make it difficult to predict the time course of the concentration of a drug and its metabolites. There are also problems in the design of a drug which has to be hydrophobic to penetrate membranes but hydrophilic to be excreted after it is metabolized. Many examples illustrated these points. P. Masturzo (Institute of Pharmacological Research "Mario Negri," Milan, Italy) described how membrane fluidity can be modulated by drugs. Berg

discussed the mechanics of one group of cytotoxic drugs, the anthracyclines, and described how changes in the molecule affect metabolic pathways and membrane transport. The best hope for ensuring action at targeted organs appears to be labeled liposomes.

The last discussion session, entitled "From Biological Membranes to Industrial Processes," was introduced by R. Buvet (University of Paris-Val de Marne, Créteil, France), who reviewed the current state of membrane technology. Biological evolution has led to very efficient ion transport and energy transduction processes in natural membranes, but industry need not be constrained by biological solutions. In thylakoid membranes, the recombination of charged species formed from the splitting of water by light is avoided by cascades of catalysts, but engineers can also use inorganic solvents and high temperatures. Nature uses bilayer membranes to orient reactions, but engineers can graft enzymes onto polymers. During the discussion, the capabilities of the Langmuir-Blodgett (L-B) technique for achieving some of the desired miniaturization and orientation effects was stressed. The L-B technique has been used to form biological types of arrays coupled to the metallic conductors required for contact with practical devices.

Conclusion

It is obvious that the topics represented here could have been covered, and frequently are, in the contexts of other disciplines--e.g., biochemistry or bioenergetics. What was special here, and perhaps even unique, was an examination of these subjects from the point of view of electrochemistry. The perspective of electrochemistry is particularly useful for considering biological problems involving charge movement (e.g., ion transport, energy transduction, and electrical excitation), and the valuable insights gained from this interaction suggest new approaches to the solutions of major problems in these areas.

12/18/84

MEDICAL OCEANOGRAPHY IN FRANCE

by Thomas C. Rozzell. Dr. Rozzell is the Liaison Scientist for Biological Sciences in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until August 1985 from the Office

of Naval Research, Arlington, Virginia, where he is Program Manager for Cellular Biosystems.

The Centre d'Études et de Recherches de Biologie et Oceanographie Médicale (CERBOM) concentrates on studies of marine hygiene, bacterial pollution of the marine environment, and chemistry and physics of the ocean.

This laboratory on the outskirts of Nice is a part of the Institut National de Santé et de la Recherche Médicale (INSERM). The director of the laboratory, Dr. Maurice Aubert, recently welcomed me to his institution and spoke at length of their research in what he calls medical oceanography, but which might also be classified as chemical oceanography or marine environmental studies. I came away with the feeling that this laboratory has a lot to offer but is not well known to US Navy researchers. CERBOM has collected a tremendous amount of data in the Mediterranean Sea, data that should be of significant value to the Office of Naval Research, the Naval Ocean Research and Development Activity, and others.

Founded in 1960, on the initiative of Aubert, CERBOM has been traditionally supported by the government, under INSERM, and by the city of Nice. CERBOM is now moving more in the direction of a semiprivate foundation with stronger ties to the city. It has been very successful in attracting industrial contracts for a variety of studies, most having to do with mineral resources and precious metals in the Mediterranean Sea.

A small laboratory by US standards, CERBOM is staffed with 30 scientists, technicians, and secretaries. Much of their research centers around their ocean-going laboratory, a 40-foot sail boat. There are five major divisions within CERBOM: (1) Department of Fundamental Research in Oceanography (oriented toward medicine and public hygiene), (2) Department of Marine Pollution (dealing with information on and control of pollution), (3) Department of Marine Ecotoxicology (primarily chemical studies), (4) Department of Ocean Economy (studies of economic techniques and utilization of the resources of the sea), and (5) Department of Oceanographic Campaigns (the sea-going group that provides the capability of carrying out the experiments for the other groups).

CERBOM emphasizes exploitation of marine resources for use in pharmacology and nutrition. This leads naturally to economic issues, and a close collaboration exists with the Department of

Economics at the University of Nice, where Aubert is a lecturer and has several students who are doing graduate work in marine economics.

Fundamental Research

Over the past 23 years, the staff of CERBOM has published about 350 research papers, the majority of which have centered around fundamental research problems. I will not try to cover all the topics that they have studied but will highlight a few areas in which they seem to be unique and seem to have concentrated a great deal of energy.

The first such area is diffusion of micro-organisms in the sea and the antagonism, or antibiosis, that exists in the marine environment. The researchers have done many studies of the interrelationships that exist between certain populations of phytoplankton and others of zooplankton. Here is an example of a type of antagonism that would seem to preclude the coexistence of the organisms in the same part of the marine environment. It has been assumed that a substance is released by phytoplankton which, in combination with photosynthesis, tends to drive the zooplankton away from the phytoplankton biomass, thus creating a rhythmic (because of the alternation of sunlight and darkness) cycle that is a defensive mechanism for the plant biomass as well as a control of the nutritional process of the zooplankton which feeds on it.

The difficulty in doing experiments in the open sea to look for an interrelationship of a biochemical nature led to some laboratory experiments where the full life cycles of microorganisms (phytoplankton and bacteria) could be developed in small volumes of water. The researchers then went to the ocean and did *in-situ* studies. Several examples of interspecies antagonism have been reported by the CERBOM group. For example, they have shown the antagonism that takes place between substances produced by a number of species of diatoms and a great number of bacteria which usually live on land but are washed off to the sea by runoff water, coastal water, or urban wastes. The researchers have been able to isolate and identify a number of chemical mediators responsible for the antagonism. They reported on the synthesis of a nucleoside and several fatty acids produced by certain species of diatoms. These have an antibiotic-like action against a great number of terrestrial bacteria. The scientists have now proven that this involves two levels of oceanic biomass. This is the type of research that leads CERBOM to believe

that there is a future for exploitation of the sea for pharmacological purposes.

A large number of papers have been published in recent years on antibiosis by phytoplankton, and the group at CERBOM has been very active in the area. They carried out experiments designed to determine the role and action of approximately 70 planktonic strains in mono-species cultures, with and without contaminating bacteria. They concluded that over 25 percent of the organisms tested were more or less antibiotic toward a wide range of microorganisms. The results found by CERBOM were unprecedented at the time because until then, at least as far as diatoms were concerned, the major part of this species was not known to have an antimicrobial action.

Here are examples of the some of the bacteria toward which antibiotic activity was found: *Staphylococcus epidermis*, *Clostridium botulinum*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella*, and *Shigella*.

The CERBOM group has also demonstrated that the order of magnitude of active-substance minimal concentrations in the extract, as opposed to the bacteria tested, is very low: from 1 to 0.005 mg/L or less, which represents an activity at least as high as that of the most active conventional purified antibiotics. Their experiments would indicate that the mere presence of phytoplanktonic organisms can account for the bactericidal capabilities of seawater.

In addition to studying the general nature of antibiosis in the marine environment, CERBOM has looked extensively at the biochemical aspects of the problem and identified the sites of action of many of the substances produced. The scientists also have deduced the chemical structure of a number of these antibiotic materials.

Other basic studies have centered around such topics as: the influence of marine bacteria in the dynamic biochemistry of metals, studies of plankton productivity in urban residential water, and direct and indirect toxicity of chemical pollutants released into the marine environment.

Applied Research

Much of the applied research has centered on ways to decrease the effects of pollution of coastal waterways by urban residential and industrial wastes that are discharged either deliberately or accidentally. The scientists have studied the movement and transfer of a number of toxic heavy metals, such as mercury, and have tried to find ways to help prevent the metals from accumulating in the environment--in fish, for

example. CERBOM researchers have studied better methods of managing streams, estuaries, and commercial and pleasure ports, and have tried to solve problems caused by pollution.

As a center of expertise, CERBOM is called upon by cities and agencies throughout France and Europe to consult on problems related to the restoration and management of beaches and shores for the maintenance of health standards. Studies have been made in the area of aquaculture, from the points of view of both production and economics. Today, this is one of the most active areas of their applied research because of its enormous potential for food production. It is no wonder that several industrial concerns (these were not named) are interested in supporting research at the laboratory.

I would also place under applied research a very large effort that has been going on for some time--the collection and analysis of data relating to the concentrations of a host of metal ions in the Mediterranean Sea. This information has been published in a series of volumes that should prove useful to chemical oceanographers who are interested in having profiles of the concentrations of such metals as zinc, iron, mercury, and lead in this part of the world.

Conclusion

CERBOM is a well-equipped, well-located, very busy laboratory that provides a vital research capability not only for France but for all the countries bordering the Mediterranean Sea. It cooperates with all of these countries in providing data on matters relating to aquaculture, chemical compositions, and biological and ecological aspects of this vast sea.

The director has indicated a willingness to cooperate with the US Navy in any way he can. This is an important resource that the Navy might be able to use more. (See page 176 of this issue for an announcement of a colloquium on medical oceanography being organized by CERBOM.)

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WIRELESS MEDICAL TELEMETRY IN EUROPE

by Thomas C. Rozzell.

The European Community (EC) recently undertook a program designed to improve the monitoring of a wide range of

critically ill patients. The leader of the project is Dr. Peter Kimmich of Nijmegen, The Netherlands. Kimmich, past-president of the International Society on Biotelemetry, is a leading authority in medical telemetry. In a recent visit to his laboratory at the University of Nijmegen, I learned about the background and objectives of the program. Much of the philosophy and many of the techniques being developed can be applied to problems of care of severely wounded military personnel.

Background

In managing critically ill patients, it is usually necessary to coordinate a multidisciplinary team of specialists such as surgeons, internists, anesthesiologists, bioengineers, and nurses. A large number of physiological variables must be monitored in such patients, both in the operating room and in intensive care units. Tubes for drug administration, flushing of indwelling catheters used for sampling and measuring purposes, and the many monitoring devices around the critically ill patient hamper the actual nursing and medical functions performed by the attending staff. Therefore, any method of reducing the clutter around these patients will enhance their care and should ultimately reduce costs.

It is in the interest of both patients and physicians to reduce the tangled web of wires and cables necessary to monitor the physiological state. The introduction of radiotelemetry brought about a substantial reduction in the number of individual leads that connect the patient to different pieces of medical surveillance equipment. To date, however, there has not been a large-scale integration of telemetric methods into clinical practice. Some of the reasons for this can be found in the physical properties of radio-frequency (RF)-wave emission and propagation and in the failure of the appropriate agencies to allocate sufficient, exclusive RF channels that are adequate for use under the stringent circumstances of clinical applications; the need for body-mounted antennae; the complexity of RF telemetry equipment, which can add to the cost of intensive care; and the requirement of battery maintenance and replacement.

It has been suggested that one solution to these problems is to transmit several variables using a single cable and multiplexing techniques to give access to several processing units from a single connecting unit above the patient. However, the lack of mechanical flexibility of existing commercial

equipment restricts such a single cable device to the sampling of just a few specified physiological variables (for example, blood pressure and heart rate) in the operating room and intensive care unit. Its rigid mechanical construction hinders the alteration or adaptation of existing systems to new requirements and adds to the high cost of complex medical surveillance.

In a workshop on Alternative Methods for Radiotelemetry held in Garmisch-Partenkirchen in May 1983, evidence was provided that showed that telemetry using infrared (IR) light transmission is particularly well suited to eliminating most of the problems associated with hardware connections.

By that time, several people, including Kimmich, had conducted some experiments and found that IR telemetry has certain advantages over RF techniques. C. Weller of the UK had reported on the use of IR in medical and biological telemetry (Weller, 1981). Between Weller and Kimmich (1982), the ideal characteristics for IR telemetry were laid out. The major advantages are as follows:

- Bulky transmitting antennae are not needed.
- Interference from RF waves is not a problem.
- Interference by other light sources is easily avoided.
- There is a large transmission bandwidth not restricted by regulations.
- There are no connector problems such as those associated with cable systems.
- Generation and detection of IR carriers can be achieved with off-the-shelf IR diodes.
- There is no interference between several systems working in different rooms.
- Identical IR systems become interchangeable and may be used throughout the hospital.
- There are no signal nulls such as those caused by directional radiation.
- There are no artifacts due to RF feedback.

In addition, IR telemetry shares the principal advantage of all wireless telemetry in that there is no risk to the patient of accidental electroshock. Not only is the patient safer, but the total cost of IR telemetry equipment is estimated to be substantially less than that of conventional wired systems because of the simple design of preamplifiers. The major cost reduction, however, is likely to be the elimination of the wire connections themselves, which

simplifies patient handling by the attending medical personnel. In military applications, there is a further advantage--a number of patients can be monitored in an open ward without RF interference.

The EC program is designed to examine all aspects of IR telemetry, including stimulation, remote control of patient functions, remote control of drug delivery, and patient location. The project aims to achieve this through close cooperation between scientists involved in technical development and clinicians involved in applications. The development of IR systems has progressed to a point where further decisions for development can only be made jointly by the engineers and clinicians involved. This should ensure an optimal design that satisfies clinical needs. The aim of the cooperation is to produce a low-cost, clinically tested IR system. For this reason, 20 institutes have been chosen from eight countries to participate in the program so as to form a balanced group of scientists, engineers, and physicians involved in both the development and application of IR telemetry and in the care of critically ill patients.

Details of the Program and Time Schedule

The working program is divided into four phases of approximately 1 year each. The project leader (Kimmich) and the project management group (M. Bornhausen, Munich-Neuherberg, West Germany; W. Erdmann, Rotterdam, The Netherlands; and Weller, UK) are responsible for seeing that the tasks, as stated in the different phases, are completed on schedule. Based on results obtained in a previous phase, succeeding phases may be redesigned, but never at the cost of a general delay in the working program.

1. Phase I (1984):

a. A detailed review and comparison of existing IR-biotelemetry systems, especially their practical limitations.

b. Further clinical tests with existing equipment that is presently suitable for clinical use.

c. Suitability tests with IR equipment not primarily designed for clinical use (e.g., tests concerning adaptation of animal equipment for human applications, such as for stimulation and transcutaneous measurements).

d. Investigation of the processing and display of patient data obtained through an IR transmission system.

2. Phase II (1985):

a. Investigation and design of an optimal setup for the operation of several identical IR systems in a single enclosure (hospital room).

b. Investigation of transponding devices to be used on large areas of non-IR-reflecting material (glass).

c. Evaluation of the clinical tests of Phase I: needs for improvement of signal transmission; general operation requirements; list of physiological variables, suitable for initial clinical routine investigations; other practical considerations.

d. Procurement, adaptation, and/or development of suitable IR transducers for physiological variables as decided in (c) of Phase II.

e. Improvement of signal transmission as required in (c) of Phase II.

f. Development of new system-oriented processing and display equipment specifically adapted to IR telemetry.

3. Phase III (1986):

a. Prototype development of IR patient-monitoring systems.

b. Preliminary clinical tests with the selected transducers and further matching to the IR systems in design.

c. Integration of the newly developed processing and display equipment with the IR system prototypes.

d. Evaluation and critical survey of IR systems for transcutaneous transmission, stimulation, and drug delivery with a view to incorporation of such systems into the general IR patient-monitoring system.

4. Phase IV (1987):

a. Completion of the IR patient-monitoring systems and preliminary clinical evaluation.

b. Evaluation of the results of (a) of Phase IV and elaborations of directives for the design of extensive IR patient-monitoring systems suitable for general use with an extended package of physiological variables.

c. Survey of the first group of physiological variables as decided in (c) of Phase II leading to directives for their extension (IR-telemetry-suitable variables and transducers).

d. Completion and integration of processing and display units into the IR monitoring system. Evaluation of the suitability of the complete system for extensive clinical use.

Conclusion

This project was approved in February 1984, and the contract went into force in July. It was not until September that the money was actually received and the work could formally begin. However, the first phase was completed by the end of 1984 because the work went on in anticipation of the contract. At the end of a 4-year period a small, inexpensive IR monitoring system should be available that would, for

example, monitor four variables from up to 16 patients located in the same or different IR transmission areas (e.g., an operating room, an intensive care unit and two rooms in the ward). If successful, this project will probably be the determining factor in the ultimate use of IR telemetry in patient care and monitoring. For this reason, it is a program that bears watching.

References

- Kimnich, H.P., "Biotelemetry, Based on Optical Transmission," *Biotelemetry and Patient Monitoring*, 9 (1982), 129-143.
- Weller, C., "The Use of Infrared in Medical and Biological Telemetry," in *Medical Wireless Telemetry* (Commission of the European Communities, proceedings of a workshop in Lyon, 1981), 46-51.

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Computer Sciences

HERIOT-WATT UNIVERSITY DEVELOPS CAD SYSTEM FOR AUTONOMOUS SUBMERSIBLE VEHICLE

by J.F. Blackburn. Dr. Blackburn was until September Liaison Scientist for Computer Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is now the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

Researchers at Heriot-Watt University, Edinburgh, Scotland, have developed a computer-aided design (CAD) facility to generate automatic guidance and control strategies for an unmanned, autonomous, submersible vehicle. Until recently most research was on tethered submersibles; Heriot-Watt's work is the first step toward development of an autonomous vehicle.

The CAD facility, designed by George Russell and his colleagues, uses a three-dimensional color graphics display of the scene and vehicle trajectory, providing a man-machine interface for the operator in addition to vehicle-motion simulation with six degrees of freedom. A primary application for the

CAD facility is the design of scene-analysis algorithms and the intelligent control system for an autonomous submersible vehicle employing sonar as its target sensor.

Background

The offshore oil and gas industry uses a range of tethered, unmanned, submersible vehicles for inspection, survey, and diver support. Heriot-Watt University has an extensive research program on submersible systems which has led to the construction of three cable-controlled vehicles, including a real-time computer guidance and control facility. Recent work has been concerned with designing submersible systems that have no physical connection with surface support. Such vehicles could be useful in under-ice surveys, long-range operation from a support vessel, deep ocean operation, operation near and inside offshore platforms, and high-speed pipeline survey.

Effective simulation studies need to be done on intelligent activity functions well in advance of practical trials work of systems suitable for sub-surface use. An important consideration is the use of sonar and video data in an intelligent guidance and control strategy for obstacle avoidance and traversing. The CAD facility has been developed at Heriot-Watt with three main functions:

1. Computer-aided generation of simple three-dimensional environments.
2. Interpretation of this three-dimensional environment to generate two-dimensional perspective views of the scene and the submersible vehicle.
3. Interpretation of the three-dimensional environment to generate simulated sonar images, based upon the submersible vehicle position, orientation, and selected sonar scan.

Hardware

The CAD work uses a UNIX operating system and a UNIX-based interactive digital image processing system. The hardware to process the image information is a Digital Equipment Corporation (DEC) PDP 11/44. The low-level image capture and display is controlled by a dedicated slave, a DEC LSI 11/02, interfaced to a large software programmable frame store with video output hardware. The frame store unit comprises 19 1024x512x1 bit memory cards capable of being configured and multiplexed for output to three programmable random-access-memory modules acting as hardware look-up tables. Outputs from these tables are interpreted as red, green,

and blue components of a color signal and are fed to three digital-to-analog converters operating at video rates. Appropriate synchronization signals for the raster scan are included, and analog red, green, blue signals produced for display on a RGB/PAL monitor. The hardware can handle image resolutions up to 1024x512 at 6 bits per color, 18 bits per pel, and the storage provided in the frame store is large enough to maintain and display up to 24 monochrome images at a resolution of 256x256.

Software

Processing programs are mainly written in the C programming language and reside in the host computer (DEC PDP 11/44). These programs implement image-processing algorithms on one of a series of digitized images held on disk, and they incorporate library processing routines, which handle file input/output and certain other functions (e.g., orthogonal transforms).

Display programs run in the host computer and the slave, and are written in C and in the assembly language of the two computers. They supervise the control and data communications between computers for capturing, displaying, or storing images.

Satellite programs run exclusively in the slave. Their functions affect the contents of the frame store and output look-up tables, and therefore affect the display. They are written in LSI/11 assembly language.

The software interface seen by the user is through UNIX and the host computer. This standard high-level interface helps multiplex the use of the single frame store in a multi-user processing environment.

Three-Dimensional Environment Generation

The emphasis of the CAD facility in designing the three-dimensional environment is on handling small amounts of information in a fashion most suited to a potential user's need--i.e., readily specifying a new three-dimensional environment.

For representing three-dimensional shapes, polygons and polyhedra require less computing than other methods of representation and were considered most appropriate. A designer specifies a three-dimensional environment by writing a computer program in accordance with rules, such that both polygons and polyhedra are used as bases (or primitives) for composing larger objects. This allows the designer to use the newly generated polyhedron as a primitive in a larger object.

Typical shapes for a set of standard polygons may be squares, triangles,

octagons, or some more abstract form with straight edges, all defined as having a particular dimension and orientation at the origin. For building objects they need to be translated, oriented, colored and stretched in three dimensions. A first routine may be defined as:

polygon (size, position, orientation, color).

Such a routine, when called, would generate the specified polygon in the x, y, and z directions. A sequence of such level zero routines could be called to create shapes such as stars from an octagon and eight triangles connected together.

Higher level routines formed from particular polygon combinations may form boxes, columns, tetrahedrons, or other more abstract polyhedra. The hierarchic use need not be limited to two levels, but can be carried to high levels with more complex objects as primitives.

With hierarchic design structure, a particular polygon undergoes a series of three-dimensional transformations as it is positioned and oriented at level zero and then at higher levels. The concatenation of rotation, translation, and scaling is not commutative, and so the order of operations must be preserved.

Interpretation for Graphical Display

Standard algorithms derived from available literature have been used at Heriot-Watt to generate synthetic two-dimensional images for subsequent display on a raster device. The inertial-to-screen coordinate transformation uses position and Euler angles of the observer to generate a suitable directional cosine matrix. The perspective transformation and the polygon clipper are a direct implementation of a published algorithm (Sutherland and Hodgeman, 1974) which uses efficient reentrant coding to achieve the result. The hidden surface algorithm used is that of Watkins (1970) and is a scan-line algorithm operating in the image space. Two extensions to this algorithm were made at Heriot-Watt. The first allows for the generation of scenes where the perspective depth value of points on visible polygons is displayed as a pixel grey level. This is in preference to the polygon color contained in the database, and produces images where close objects appear bright and distant objects are dark. The second extension allows for a shading algorithm to be included, using a standard shading law:

$$I_n = I \left\{ I_a + \frac{I_r \cos \theta}{Z} \right\}$$

where Z is the range to the polygon from the light source, I_a is the ambient illumination, I_r is the reflected illumination, θ is the angle between the vector to the light source and the normal to the polygon, and I is the polygon color. The shading law is used as a multiplicative factor on red, blue, and green components, which gives the resulting image a little more three-dimensional effect.

Interpretation for Sonar Display

Generation of synthetic sonar images based on knowledge of the submersible vehicle's position and orientation, and the synthetic environment, is a prerequisite to any filtering and segmentation functions in the simulation process. These images must be generated dynamically with the motion of the vehicle simulation.

A within-pulse sector scanning sonar scans a wedge-shaped sector in three-dimensional space. An omnidirectional acoustic pulse at a typical frequency of 100 kHz is used to insonify the sector immediately to the front of the sonar. During the period in which the reflected echoes from objects arrive at the sonar, the collection of maximum sensitivity of the receiving array of sensors is electronically swept, repeatedly and very rapidly, across the selected scan angle. This beam is at right angles to the orientation of the receiving array. The frequency at which the sweep is performed defines the resolution in range of the sonar system, as well as the length of the insonifying pulse. The term "within-pulse" arises because the beam is required to sweep the specified sector once within the length of an emitted pulse. A complete image of the scene can be built up once within the time span defined by the interval required for the pulse to travel to the maximum selected range, and for any echoes to return. Typically at 100-m range and for a 30-degree sector, a within-pulse device is theoretically capable of providing an image once every 0.15 seconds with range resolution 0.075 m and angular resolution defined by the number of sensors in the receiving sensor array.

Simulation of such a device involves the geometric aspects, the nature of the echo, and the noise components.

Geometric Aspects

The geometric aspects involve computing which objects are within the range of the sonar, and their location in the insonified field. The inertial-to-screen coordinate transformation uses position and Euler angles of the submersible vehicle to derive a suitable

cosine matrix. Polygons present in the database file are thus suitably reoriented. A polygon clipping stage is necessary prior to computation of a sonar image. The viewing volume is no longer a pyramid, but a three-dimensional slice of a sphere with maximum point R , at the limit of the range of the sonar. The revised clipping limits for the algorithm of Sutherland and Hodgeman are:

$$0 < \sqrt{x_s^2 + y_s^2 + z_s^2} < R$$

$$-z_s \tan \frac{\gamma}{2} \leq y_s \leq z_s \tan \frac{\gamma}{2}$$

$$-z_s \tan \frac{\alpha}{2} \leq x_s \leq z_s \tan \frac{\alpha}{2},$$

where (x_s, y_s, z_s) are the screen coordinates of polygon vertices, α is the horizontal scan sector, and γ is the vertical beamwidth.

The image-space algorithm of Watkins relies on an orthogonal projection of polygons, suitably distorted by perspective, to achieve the final image. The approach is not justified because the sonar can resolve in x_s and z_s directions only--because of the beam shape, and because sonar relies on spherical wave-fronts for pulse and echo actions. The above implies that an (r_s, θ_s, ϕ_s) spherical formulation is more appropriate than an (x_s, y_s, z_s) rectangular formulation. Whereas in the standard scan-line hidden surface algorithm at each raster line (integer value of y_s) the z_s values of all currently present polygons are compared, for this formulation it is more appropriate to take each contiguous range slot (for example, y_s) and scan around each horizontal bearing (x_s) examining all polygons in the vertical beam slice (z_s). Conceptually, whereas the scan-line algorithm scanning is in rectangular coordinates along the front (x_s - y_s) face of the viewbox, the sonar scanning action is in polar coordinates along the top face (R - α_s) of the insonified semi-sphere.

Nature of the Echo

A hidden surface algorithm attempts to decide which (if any) polygons are visible at a particular pixel by comparing their depth values, thus deriving display information. For the sonar at each pixel (range and horizontal bearing position) the cumulative effect of echoes due to reflections from all polygons in the vertical slice has to be computed. Exact computation of this cumulative effect is extremely complex. However, there is a similarity with the problems of computing illumination effects in conventional three-dimensional graphics situations. The same physical

parameters determine the nature of the effect. As with three-dimensional graphics illumination, approximations are required to make computation manageable. Rules similar to those discussed under Interpretation for Graphical Display on page 145 are appropriate.

Noise Components

The effects of the noise encountered can be introduced by specifying the noise statistically using its spectral-density distribution, its mean value and the signal-to-noise ratio imparted on the image. The results of the central limit theorem (Papoulis, 1965) predict that the overall spectral-density distribution will be Gaussian, and that it can be included in an additive fashion. Further noise components are introduced as blank radial lines corresponding to misfiring of the transducers at particular bearings, and strongly correlated semicircular reflections corresponding to echoes from thermocline and halocline boundaries.

Conclusion

Heriot-Watt's CAD work for a submersible vehicle highlights three areas:

1. Computer-aided generation of a three-dimensional environment in which to drive a six-degree-of-freedom, dynamic simulation of the submersible vehicle motion.
2. Interpretation of this three-dimensional environment to generate two-dimensional perspective views.
3. Interpretation of the three-dimensional environment to generate simulated sonar images.

References

- Papoulis, A., *Probability, Random Variables and Stochastic Processes* (McGraw Hill, 1965).
- Russell, G.T., and D.M. Lane, "CAD for Intelligent Activity of an Autonomous Submersible System," in *Computer Graphics Forum 3* (North-Holland, 1984).
- Sutherland, I.E., and G.W. Hodgeman, "Re-entrant Polygon Clipping," *Communications of the Association of Computing Machinery*, Vol 17, No. 1 (1974).
- Watkins, G.S., *A Real-time Visible Surface Algorithm*, UTEC-CSC-70-101 (University of Utah Computer Science Department, 1970).

Material Sciences

GAS TURBINE TECHNOLOGY FEATURED AT UK CONFERENCES

by R.L. Jones. Dr. Jones is Head of the High Temperature Chemistry Section in the Chemistry Division at the Naval Research Laboratory, Washington, DC.

Gas turbine technology was the subject of two conferences held in England last November. The first conference, Protective Coating Systems for High Temperature Gas Turbine Components, convened in London under the sponsorship of the Metals Society. There were about 150 participants--principally from the UK, the US, Sweden, France, and West Germany. After this meeting, many UK and US conferees went to Bath for the UK-US Navy Workshop on Gas Turbine Materials in a Marine Environment. This was a restricted conference of about 60 engineers, scientists, and naval officers involved with ship propulsion gas turbines in the UK and US Navies. The proceedings of the Metals Society Conference will be published, but papers from the Navy Workshop will be for official use only.

Coating Systems

The Coating Systems Conference opened with an overview by G.W. Goward (Turbine Components, Branford, Connecticut) detailing the development of protective coatings for turbine blades and other gas turbine components from the 1950s to the present. With this paper providing perspective, there followed sessions on coating processes, mechanical properties and structural stability of coatings, corrosion properties, service experience, and future prospects for new coating developments.

Since gas turbine coatings are a relatively mature technology, and most of the presentations were in fact reviews, the feeling of the conference was not "breakthrough" but rather "regrouping"--i.e., where do we go from here? Alternative coating processes were discussed in detail, but none was seen as replacing the three current major processes (pack cementation, physical vapor deposition [PVD], and plasma spraying). One exception may be pulsed pressure aluminizing, as described by J.E. Restall (Royal Aircraft Establishment, Farnborough), which is similar to pack

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cementation aluminizing but uses gas phase aluminum halides. By cyclically varying the pressure in the coating chamber, the internal cooling passages as well as the external surfaces of a turbine blade can be aluminide coated in one operation. Moreover, up to 1000 blades can be coated simultaneously (in a large-scale coating apparatus), making the process highly manpower efficient. Few "new" coating compositions were revealed beyond, for example, the addition of elements such as Ta or Si to existing aluminide or MCrAl (M=Co, Ni or Fe) coatings. Optimization of precious-metal-augmented aluminide coatings is being pursued, especially in Europe, since these can be cheaper, but give equal performance to MCrAl coatings in many cases.

In the sessions on mechanical properties and corrosion resistance, two papers seemed to me unusually significant. W. Esser (Kraftwerk Union, AG, Mülheim, West Germany) reported that the 950°C strength of certain superalloys was substantially reduced by only 1 ppm of salt in the furnace gas (the effect was avoided if the superalloys were coated). Study of the influence of environment on high-temperature strength is not new in Europe (see the proceedings of the Petten Symposium on Corrosion and Mechanical Stress at High Temperatures, and the 1982 COST-50 proceedings). But it has been generally neglected in the US, and perhaps should not be, with the future prospect of lower fuel quality and higher stress levels in gas turbines. In the second paper, G. Booth (Admiralty Research Establishment [ARE], Poole), discussed burner rig evaluation of blade coatings. Booth described how slight changes in combustion--observable in that the flame changed from blue to luminous yellow--caused a marked acceleration in hot corrosion, even though all other conditions remained constant. The phenomenon is still under investigation at ARE, but may result (in my opinion) from homogeneous gaseous catalysis of the oxidation of SO₂ to the more corrosive SO₃ in, or downstream from, the luminous flame. The event serves admirably, in any case, to illustrate the subtleties involved in hot corrosion.

Another well-received paper was by A. Bennett (Rolls Royce, Derby) on thermal barrier coatings (TBC). Studied for some years now, TBCs are usually 8 to 12 wtg-percent Y₂O₃ stabilized ZrO₂ coatings which, because of the insulative properties of ZrO₂, can reduce blade temperature by up to 150°C. This effect could increase engine efficiency by 10 percent or more by allowing higher

turbine gas temperatures; however, if used to full thermal advantage, TBCs become critical since their failure could lead to local overheating and rapid disintegration of the blade. Bennett's presentation summed up Rolls Royce progress on ensuring the integrity of TBC coatings in various applications, while providing a thought-provoking review of the factors which affect TBC life. The properties of ceramic coatings are much different from those of metallic coatings, and are apparently quite dependent on the exact processing employed. Zirconia coatings are usually plasma sprayed (although they can also be deposited by PVD), and A.R. Nicoll (Plasma Technik, Wohlen, Switzerland), as a part of his closing presentation on future coatings, noted that there are now advanced techniques which, by reducing porosity and active element segregation, may significantly improve plasma-sprayed zirconia TBC coatings.

US-UK Navy Workshop

The Bath workshop was the fifth (and unfortunately perhaps the last) of a series of conferences that began in 1972. These meetings have allowed the UK and US navies to share information on the "marinization" of gas turbines for ship propulsion.

The major problem in running gas turbines at sea is molten salt corrosion of the hot turbine blades caused by sea salt and fuel impurities. This "hot" corrosion, which can devastate unprotected engines, is fought in a variety of ways, including intake air filtering, fuel quality control, and development of corrosion-resistant blade superalloys and coatings. Therefore, the UK-US conferences have traditionally been of broad spectrum. The 1984 Bath workshop was no exception, with sessions on fleet experience; fuels and treatment; coating and superalloy evaluation; corrosion mechanisms; and new alloy and coating development (performed and reported by industry, e.g., General Electric, INCO, United Technologies, Rolls Royce). This multidisciplinary approach is the merit of the UK-US meetings, since it produces a meeting of people and exchange of ideas, all intimately related with hot corrosion, that otherwise would not occur.

The controlling of hot corrosion appears at this time to be largely successful, with blade lives of 7000 to 10,000 hours being reported at Bath as not uncommon for US ships. Good results are also being achieved in UK ships; indeed, the British Ministry of Defence plans to reduce marine gas turbine materials R&D (which may end the UK-US

conferences). However, several conferees voiced concern that the excellent blade lives may be a "peacetime phenomenon," and result from good fuel and strict air filter and fuel system maintenance as much as the inherent corrosion resistance of current blade materials, improved though they may be. This idea is supported, for example, British experience in the Falklands, where clogged fuel filters apparently caused accelerated turbine-blade corrosion. There was also concern over the crisis that could arise if vanadium-containing fuel had to be used (which some sources regard as inevitable)--since, as shown by L. Aprigliano (David Taylor Naval Ship Research and Development Center, Annapolis), as little as 10 ppm V substantially increases the hot corrosion of current blade coatings.

The materials scientists offered new solutions to hot corrosion problems, with the announcement of two superalloys, IN6201 (INCO) and single crystal Navalloy 300 (United Technologies), developed under UK and US Navy funding, respectively, which give equal or greater high-temperature strength and hot corrosion resistance that is two to four times higher than present bill of material alloys. New coatings increasing blade life by more than two times were also reported by ARE (Poole), General Electric, and United Technologies. The improvement here comes mainly from increasing the 700°C hot corrosion resistance of the coatings; earlier UK-US investigations showed that hot corrosion occurs in both 700°C and 900°C temperature regimes, and that blade materials must be optimized for corrosion resistance at both temperatures. Future generation materials were represented by papers on preliminary work aimed at adapting zirconia-based ceramic coatings to marine application; the immediate goals are improved processing (perhaps by PVD), and enhanced corrosion performance by, for example, replacing the Y_2O_3 stabilizing additive with corrosion-resistant CeO_2 .

On leaving Bath, I was impressed first by the "tightrope" between materials development and never-ending demands for higher strength and longer life in increasingly aggressive gas turbine environments, and second by the progress that has in fact been made from the initial days of marine gas turbines, when the average blade life was 500 to 1000 hours.

WELDING RESEARCH AT AACHEN UNIVERSITY

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

The Westfälischen Technischen Hochschule Aachen has two institutes solely dedicated to welding research and development: Institut für Schweisstechische Fertigungsverfahren (ISF), directed by Professor Dr.-Ing. F. Eichhorn, and Prozesssteuerung in der Schweisstechik (PS), directed by Professor Dr.-Ing. P. Drews.

The research at the two institutes overlaps slightly, but in general the emphasis is different. PS focuses on problems associated with the applications of robotics to welding, whereas ISF has a very large number of research programs covering most aspects of welding. Though much smaller than ISF and less well known, PS's work on sensors for automatic welding is state of the art and worthy of attention by US engineers. ISF, although very active in collaborative research in Europe, does not appear to have much interaction with US scientists and engineers. The research at ISF on electron beam welding (the development of beam diagnostic and automatic gap traveling systems) and the work on high-deposition-rate welding processes is very important and relevant to the US Navy's needs in the development of improved welding methods.

Drews and Eichhorn worked together at ISF until 1972, when Drews decided to form his own institute. Since then there has been little or no collaboration between the two institutes, even though they are only about 2 km apart.

Prozesssteuerung in der Schweisstechik

PS receives all of its support from government (Ministry of Research and Technology) and industrial grants. Approximately 40 people are employed at PS, including two PhDs and 10 Dipl.-Ing.'s working toward the PhD.

Most staff members have electronics backgrounds since the major work at PS is the development of sensors and control algorithms and software for the operation of welding robots. They have four robots of various designs. The most sophisticated was made by ASEA (Sweden); it has the full five axes of rotation in the robot arm, and a worktable with two axes of rotation. Considerable time is

spent at present in developing the algorithms and computer software to control the relative positioning of the welding arm and the workpiece.

The most unusual topic under investigation at PS is the development of optical sensors for automatic arc welding. A seam or weld groove to be welded is followed by using a photodiode line to produce a signal of reflected light from ahead of the welding torch. Optical fibers and a matrix camera are used in conjunction with a microprocessor to form the "image" of the seam to be welded. The microprocessor uses this image to control the welding process.

Microprocessors have been incorporated into welding power supplies so that the power supply can be programmed to perform a certain task. This is again a necessary step in the full automation of the welding process. The development of optical sensors and the programmable power supplies are worth following, but in general the effort at PS is small in comparison to that at ISF.

Institut für Schweisstechnische Fertigungsverfahren

ISF employs over 90 people; only three have PhDs, but over 25 are Dipl.-Ing's working toward the PhD. One-third of its DM4.5 million (\$1.5 million) budget is supplied by the university, another third from governmental agencies, and the final third from industry. Eichhorn has maintained very close ties with West German industry, is active in the International Institute for Welding, and has many collaborative programs with The Welding Institute, Abington, Cambridge, UK.

The largest research program at ISF involves the development of electron beam welding (EBW). For these studies a 30-kW horizontally oriented electron beam welding machine is used. ISF is addressing two very important problems: (1) gap detection and seam tracking, and (2) production of a uniform energy distribution in the electron beam and the monitoring of this energy distribution.

After several years of development, Eichhorn and his students have patented a gap/seam scanning system which uses the actual working beam. During welding, the electron beam is periodically deflected electromagnetically ahead of the fusion region and scanned back and forth across the gap/seam (about 10 times in 1 ms). Some of these electrons are backscattered and are collected and used to form an "image" of the region ahead of the fusion region. The quantity and distribution of these backscattered electrons depend on the geometry of the surface which is scanned. This image is used to direct the electron beam precisely along the seam or gap. Figure 1 schematically illustrates the principal components of this system, and Figure 2 illustrates the principles of the scanning field gap detection; as the beam is scanned ahead of the point of welding, the impulses of the gap position are located, and the position of the electron beam is altered accordingly.

This system is an important development because it has many advantages over the more conventional mechanical and optical seam-tracking systems; with EBW the weld-gap is always very small, and the region of fusion is also very small. Consequently, very precise

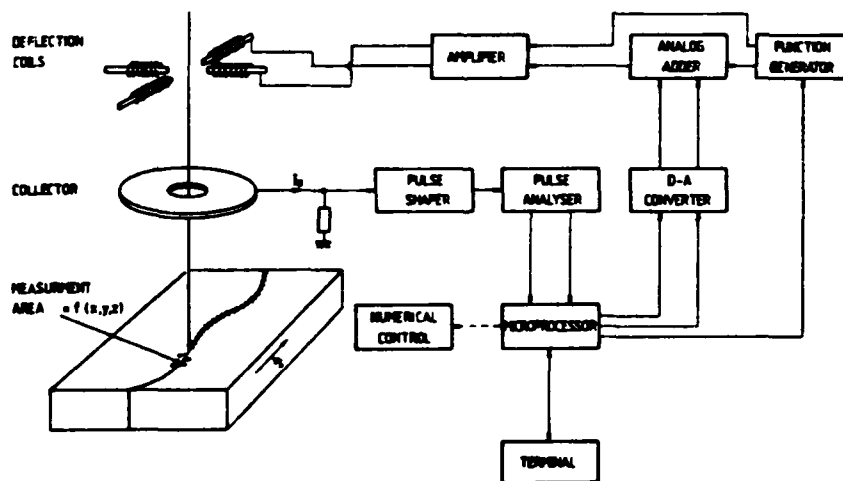


Figure 1. Conception for seam tracking with microprocessor (from Eichhorn, Spies, Depner, and Ritz, 1983).

beam/gap position coincidence is required. Manual beam positioning is not generally practical due to the high welding speed of EBW. The high welding speed also creates problems for mechanical tracking systems as they are generally too sluggish; and further, the butt-type weld joint used for EBW does not have anything for a mechanical track guide system to follow. Optical scanning has been used, but only prior to welding. The system then "remembers" the position of the gap and reproduces the path followed prior to welding. This is not satisfactory as the distortions which occur during welding due to the heating/cooling cycle can alter the position and geometry of the gap. Optical sensing during EBW is very difficult because metal vapors form and then condense on the optical systems during welding obscuring "vision."

Leybold-Heraeus has been licensed by ISF to use the electron beam scanning seam tracking system on its electron beam welding machines. (General Electric Co., US, has purchased at least one of these L-H EBW machines.)

Another major problem with EBW equipment is that the energy distribution in the electron beam is difficult to measure and thus often unknown. If the energy distribution can be measured, it is usually possible to adjust the electromagnetic lenses and the electron gun to produce a uniform energy distribution.

Eichhorn and his students have designed and constructed a point probe in the shape of a circular aperture (10- to 20- μm diameter), similar to those used in conventional electron microscopes. A Faraday cage is positioned behind this aperture and used to measure the beam current entering through the aperture. This probe is permanently fixed in the welding machine, and a pair of electromagnetic deflection coils are used to deflect the electron beam to the probe and scan the beam in two directions over the probe. The beam is deflected across the probe in the x-direction at 500 m/s. After each x-direction deflection there is a pause of about 0.1 second to keep the thermal load on the probe to a minimum. Following this pause, the beam is shifted by a defined amount in the y-direction and another high-speed scan in the x-direction is performed. This is repeated until the entire beam has been scanned over the aperture. Figures 3 and 4 illustrate a typical energy distribution measured by this technique.

This device is very simple and remains permanently fixed in the machine; the beam is electromagnetically deflected and scanned, so there are no moving

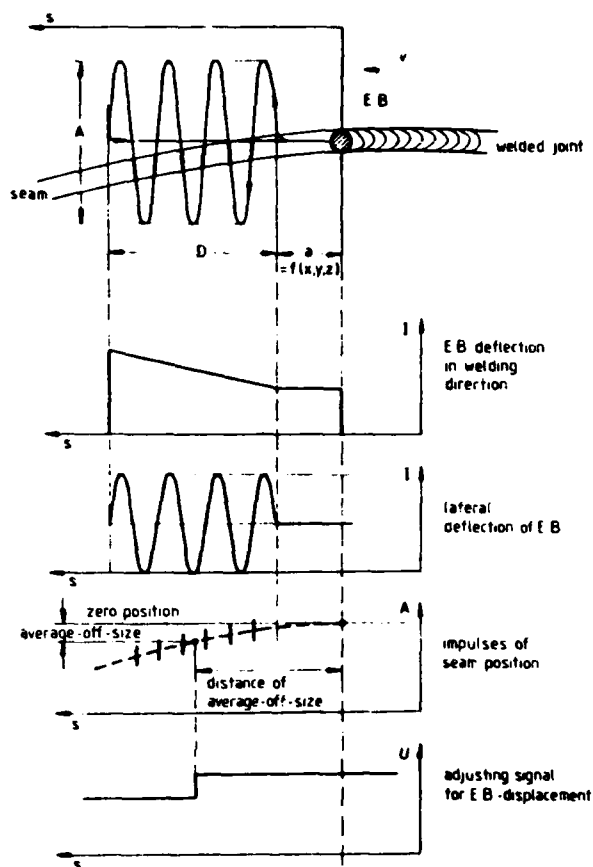


Figure 2. Principles of scanning field gap detection (from Eichhorn, Spies, and Ritz, 1979).

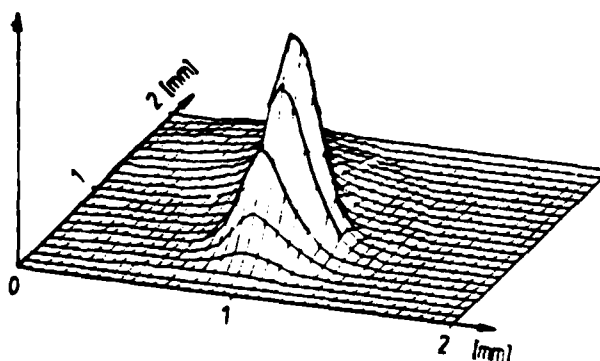


Figure 3. Perspective picture of the beam current density distribution (from Eichhorn et al., 1984).

parts to the system. This should make it very reliable and reproducible. Further, it can be used with currently existing EBW machines with only minor modifications to the machine.

Eichhorn believes that for section thicknesses greater than 5 mm, EBW will be extensively used for critical applications. If he is correct, this work at ISF will be widely exploited.

Two other large research projects at ISF are aimed at increasing the rate of metal deposition in electrosag and submerged arc welding (ESW and SAW). Conventional methods for increasing the deposition rate--e.g., increasing the heat input--always result in a decrease in strength and resistance to brittle fracture for steel weldments. New methods to increase the deposition rate without sacrificing the properties of the resulting weldment have been identified; multiple wire (electrode), strip electrode, and metal powder additions have all been studied. ESW with metal powder additions to the weld pool allows the use of a smaller weld gap and a 10× to 15× increase in the welding speed (almost as fast as conventional SAW). The fastest SAW welds have been made with three or four welding wires in tandem. Complete shapes have been built up by SAW welding. The mechanical properties of these all weld metal components appear to be better than can be produced in similar shapes by forging. (For a further discussion of this topic, see the following article.)

ISF also has a large effort (as does PS) on the development of through-

the-arc seam tracking for gas metal arc welding, (GMAW). The control system is based on the principle that the current or voltage will change as the electrode is weaved in a v-shaped groove. This is due to a change in the arc length as the side-wall of the v-groove is approached. They have developed methods for tracking very complex seam welds for both pulsed and spray transfer GMAW. Methods for applying these principles to short-circuit GMAW are under development.

In addition to these projects, ISF has very active programs on the role of hydrogen in stress relief cracking of steel welds, resistance welding of aluminum and steel alloys (for the automotive industry), high-speed electrogas welding, friction welding of dissimilar metals, and fundamental studies on the mechanism of metal transfer in SAW (using a high-speed x-ray camera and a x-ray amplifier).

Conclusion

The research at ISF is state of the art and coordinated with the other European research efforts on welding. However, Eichhorn does not appear to have many contacts in the US. I will attempt to rectify this, because his experience and the resources of ISF should be used by, and coordinated with, the US Navy's welding research programs. The research at PS, on the other hand, is very focused on robotics and thus has more limited applications.

References

- Eichhorn, F., et al., *A New System for Precise Beam Diagnosis on High Power Electron Beam Machines*, ISF Report IIW-Doc IV (May 1984).
- Eichhorn, F., B. Spies, K. Depner, and P. Ritz, "Microprocessor-Controlled Seam Tracking System for Electron Beam Welding," *Proceedings of the 3rd International Colloquium on Welding and Melting by Electrons and Laser Beam* (Lyon, France, 5-9 September 1983), 585-593.
- Eichhorn, F., B. Spies, and P. Ritz, *Gap Detection and Automatic Seam Tracking for EB Welding*, ISF Report Doc. IV-262-79 (April 1979).

1/18/85

MATERIALS TESTING AT WEST GERMANY'S EBW AND MPA INSTITUTES

by Kenneth D. Challenger.

Two of West Germany's largest organizations involved in research on the mechanical/fracture properties of

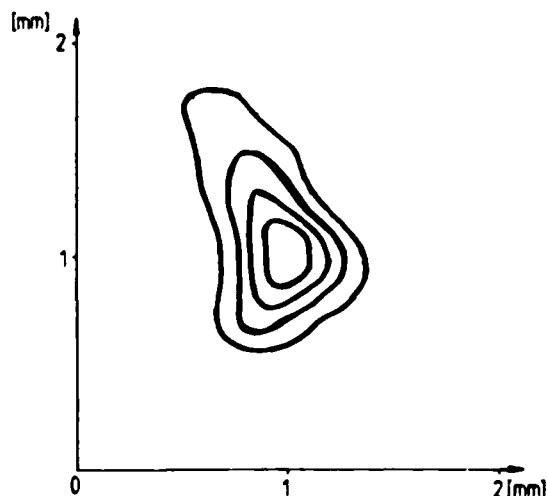


Figure 4. Curves of constant current density at 20, 40, 60, and 80 percent of the peak density (from Eichhorn et al., 1984).

structural metals are the Institut für Eisenhüttenwesen (EHW) at the Technical University of Aachen, and Staatliche Materialprüfungsanstalt (MPA) at the University of Stuttgart.

EHW is involved in all phases of ferrous metallurgy, with emphasis on mechanical/fracture properties, whereas MPA's programs are focused on materials testing, structural analysis, and materials qualification. Both institutes are performing research that is complementary to research at the US Naval Research Laboratory and the David Taylor Naval Ship Research and Development Center. MPA seems keen to take part in collaborative research and, because of the unique testing facilities for dynamic fracture at MPA, this should be considered. The research at EHW on the ductile-to-brittle transition behavior of steels is an important step in understanding this undesirable characteristic of steel.

Institut für Eisenhüttenwesen

EHW, the Institute for Ferrous Metallurgy, is one of seven institutes in the Department of Metallurgy at Aachen University, and this department is one of three departments in the Faculty of Mining and Metallurgical Engineering. The Department of Metallurgy is the largest department for undergraduate education in metallurgy in West Germany, with over 800 students and 19 professors distributed among its seven institutes. Aachen University has a total enrollment of over 35,000 students and employs about 550 faculty and over 6,000 academic and administrative staff.

EHW has five professors; Professor Dr. rer. nat. W. Dahl is the head of the institute. Funding for the institute is evenly distributed among the university, governmental agencies, and industry, and its total budget is approximately DM10 million (\$3.3 million per year). The institute employs a total of 160 people, including about 80 Dipl.-Ing., who are working toward their PhDs. The major research themes and project leaders are: ironmaking, Professor Dr.-Ing. H.W. Gadenau; steelmaking, Professor Dr.-Ings. T.El Gammal and K.W. Lange; physical technology of high temperature processes, Priv. Doz. rer. nat. F.R. Block; and materials science, Professor Dr. rer. nat. W. Dahl (also head of the institute).

During my visit I had discussions with the students and staff in the materials science group under Dahl's supervision. Although this group is called materials science, its research is almost entirely focused on the stress-

strain and fracture behavior of steels; strain hardening, fracture mechanics, fatigue fracture, and fracture mechanisms as influenced by chemical composition, temperature, processing history, and environmental degradation are all under investigation.

Most of the mechanical properties of iron alloys depend on the strain rate or loading rate employed to measure the properties. It is very important to take this into account when designing a structure that may be subjected to a wide range of loading rates. (Note: although the loading rate of a structure may be low, the local strain rate at a crack tip region can be very high, and it is the local mechanical properties in the vicinity of the crack tip that will determine the integrity of the entire structure.) Earthquakes and explosions are two examples of design conditions that must include the effects of loading rate on the mechanical/fracture properties of the structural materials.

Dahl and his students have been studying this topic for several years now. Recently they have shown that the yield strength of ferritic/pearlitic steels is more strain-rate dependent than the yield strength of steels with a modified microstructure, i.e., martensite or bainite. Additionally, they have shown that for steels with different yield strengths, the thermally activated (strain-rate dependent) portion of the yield strength is the same for all of the steels, and the difference in strength is due to the athermal component. Thus, as the yield strength increases, the strain-rate dependence of the mechanical/fracture properties is expected to decrease. They have shown this to be true for steels with yield strengths ranging from 200 to 630 MPa.

Hot cracking during solidification of castings, ingots, and weld metal is under study at EHW. In a recent study they found that manganese sulfide inclusions in steel had their shape altered in the fusion zone of a weldment. These sulphides are in the form of platelets prior to welding, whereas their shape in the fusion zone after welding has been found to depend on the amount of restraint present during solidification of the fusion region. Globular sulfides were formed when there was no restraint on the weldment, but the sulfides formed film-like shapes after welding under restraint. The globular shape has no effect on the mechanical/fracture behavior, but the film-like shaped sulfides reduced the ductility, the fatigue endurance limit and the fracture resistance of the weldment.

The main object of my visit was to review Dahl's research programs on the ductile-to-brittle transition in the fracture behavior of steels and his work on correlating laboratory fracture tests with the fracture of full-scale components. I discussed these programs with Dipl.-Ing. W. Wesse, who has been working with Dahl on these topics for about 5 years (PhD expected in early 1985). They have learned that their findings on the strain-rate dependence of the mechanical behavior of steels can be used to explain the effect of strain rate (static versus dynamic loading) on fracture toughness. Wesse has developed a correlation which describes (and predicts) the temperature dependence of the plane strain fracture toughness, K_{IC} , of steels resulting from different rates of loading. The magnitude of the shift in K_{IC} due to increases in the loading rate depends on the strain-rate sensitivity of the steel, m , where $m = \partial \ln \sigma / \partial \ln \dot{\epsilon}$ (σ = stress and $\dot{\epsilon}$ = strain rate). This work is especially relevant to the safety analysis of nuclear power plants involved in, say, earthquakes or aircraft crashes, and naval vessels involved in explosions or collisions.

In order to assure that laboratory fracture-toughness tests will accurately predict the behavior of full-scale components, wide plate tests (up to 1-m wide by 200-mm thick) with and without welds are tested to fracture with a variety of different defects present in the test plates. The laboratory tests, combined with finite element analyses of the wide plates, are used to predict fracture in these plates using various methods of integrity assessment; the J-integral approach, the UK Central Electricity Generating Board's R6 analysis (see ESN 38-8:432-434 [1984]), and an approach under development in West Germany have all been used. The primary result to date is that the J-integral can describe the behavior of a structure if the temperature for stable crack initiation, T_i , is the same or higher for the large structure as T_i for the J_{IC} determined by laboratory test. If T_i of the structure is lower than that of the laboratory tests, fracture will occur sooner than the laboratory tests would predict.

This work is very relevant to the US Navy's research programs on fracture being carried out at the Naval Research Laboratory and David Taylor Naval Ship Research and Development Center.

Materialprüfungsanstalt

MPA, the State Institute for Materials Testing, is a very old research institute that has undergone some very

impressive expansion during Professor Dr.-Ing. K. Kussmaul's reign as its head. All aspects of the mechanical/fracture behavior of metallic materials are being actively investigated at MPA. In addition to modern state-of-the-art facilities for the standard laboratory testing, MPA has vast facilities for very-large-scale-component/structural testing. In addition, an impressive new computer complex has been built. (It has a VAX 11/785, and a CRAY 1M interfaced with VAX 11/780, CDC 835, and IBM 3083.) This computer facility is used for data collection and analysis from the laboratory and component tests and is used for finite element analyses and design code developments. The main emphasis of the research at MPA is very clearly shown in Figure 1. All aspects of the testing and computations necessary for the assessment of the structural integrity of engineering structures are investigated, including theoretical and experimental stress analysis, metallurgical aspects of fracture resistance, specimen shape/size effects on fracture resistance, and the development of nondestructive inspection methods.

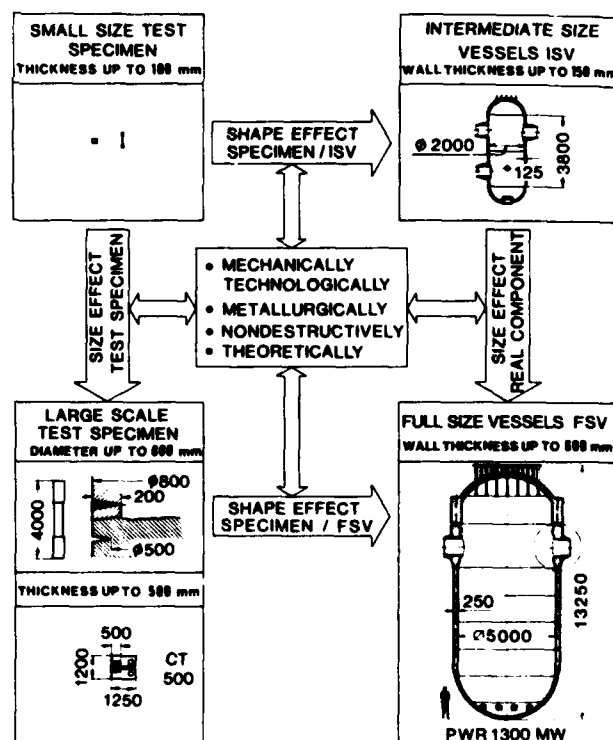


Figure 1. Investigation of size and shape effects in the research project "Integrity of Components" (from K. Kussmaul, "New Testing Facilities at MPA Stuttgart" [MPA Report, 1980]).

Approximately 300 people, of whom 120 are engineering graduates working toward the PhD, are employed at MPA. MPA is one of many institutes associated with Stuttgart University; over 150 undergraduates are trained at MPA each year. MPA receives most of its funding from the Federal Ministry for Research and Technology, the Economics Ministry and the Ministry of Science and Art of the Land Baden-Württemberg, and the University of Stuttgart. Kussmaul is very active in international circles; for example, he frequently provides testimonies for the American Society of Mechanical Engineers Code, and he maintains close connections with the US Nuclear Regulatory Commission (Dr. Shafik Iskander is the current NRC resident engineer at MPA.)

With its very close connections to the West German industry, MPA has many opportunities that are unique for a university institute. For example, a 900-MWe boiling water reactor pressure vessel was installed at MPA for non-destructive and destructive testing. The vessel was obtained at no cost to MPA as it was unacceptable for its intended use due to a material specification change by the electric utility that had bought it. This vessel (6500-mm diameter by 141-mm wall thickness) is installed in a testing pit at MPA. The vessel is now being used for the verification and application of nondestructive testing equipment and methods both by MPA and industry (Kraftwerk Union AG [KWU]). Natural and artificial defects have been introduced in the vessel for this purpose.

A piping test rig has been constructed in order to study the reaction of piping systems to combinations of horizontal (up to 3 MN) and vertical (up to 4 MN) forces; incidents such as earthquakes, aircraft crashes, and reactor blow-down can all be simulated in this rig.

MPA has a very large program on dynamic fracture studies. Four separate testing facilities are used. Figure 2 summarizes their capabilities. Three of these facilities are in use, but the 12-MN explosion tearing machine is still being assembled; it was scheduled for its initial testing in the first quarter of this year. It should be spectacular to see in operation. It will have an accelerating force of 100 MN and should be capable of loading rates up to 60 m/s. The rotating disk impact machine is capable of loading rates of 150 m/s, but only relatively small samples can be tested. A high-speed (20×10^6 frames/s) image converter camera has been used recently to record the fracture of

conventional fracture mechanics (CT) test specimens. These specimens had a lined grid etched on their surface so that the displacement field ahead of a rapidly propagating crack can be measured and compared to theory. Ten years of development have been spent on rotary disk impact testing, and a detailed description of the measuring techniques will be published shortly.

In addition to these large testing facilities, MPA has a modern, well-equipped metallurgical laboratory.

Kussmaul and MPA are involved in many collaborative projects. One of the most noteworthy recent projects of this type has resulted in the formation of a new subsidiary of Thyssen, namely Thyssen Heavy Components. MPA collaborated with Blohm and Voss Shipyard (another subsidiary of Thyssen) in the development and production of a submerged arc, shape-welded (all weld metal construction) pressure vessel. The vessel produced during this collaboration was from A-508 class 3 steel (reactor pressure vessel material) and measured 1840-mm outside diameter (OD), by 350-mm wall thickness, by 7.5-m long, and had a shape-welded hemispherical head welded to one end. This vessel has been subjected to a variety of nondestructive and destructive tests at MPA. The very fine microstructure of the weld metal has resulted in strength levels almost twice that found in a forged and heat-treated vessel of the same alloy. At present, the remainder of the vessel is at KWU undergoing testing to qualify the material for use in nuclear applications. Already the chemical industry has accepted the shape-welded process for hydrocracker pressure vessels. Thyssen

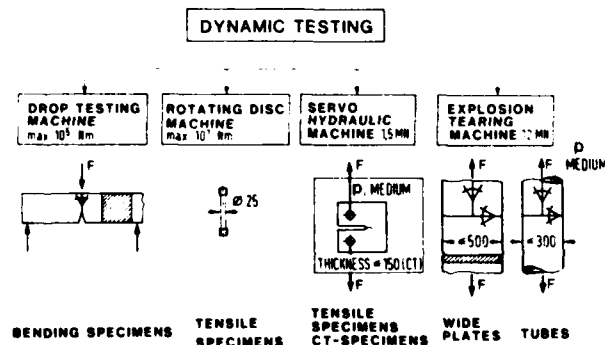


Figure 2. Testing concept and machinery to realize dynamic loads on specimens and component-like structures (from K. Kussmaul, "New Testing Facilities at MPA Stuttgart" [MPA Report, 1980]).

Heavy Components has supplied seven shape-welded 3.5-m OD, by 190-mm wall thickness, by 18-m long pressure vessels made of all weld metal 2½Cr-1Mo steel (total weight of over 300 tons each). The higher strength material of the shape-welded vessels allows the wall thickness to be reduced from 400-mm thick (for the conventionally manufactured pressure vessels) to 190-mm (for the shape-welded vessels). This results in a tremendous overall savings in the construction costs and actually lowers the thermally induced stresses in the vessel during operation.

MPA has a continuing program to carefully determine the parameters which control the residual stress in the shape-welded components so that pre-stressing of the vessel can be fabricated into the vessel during its construction. This is an exciting new development in thick-section technology that is now commercially available in West Germany. With this technology the West Germans can, in some instances, be more competitive than the Japanese in construction of thick-section components.

I believe that Kussmaul would be very interested in discussing the idea of collaboration with the US Navy. Many international visitors have spent up to 1 year at MPA investigating topics of mutual interest. These options are probably open to the US Navy and should be pursued.

Summary

West Germany has several institutes studying the mechanical behavior of metallic materials. The two discussed in this article are perhaps the largest of those associated with a university. EHW and MPA educate a large fraction of the West German metallurgists and thus have a very strong influence on the future developments in this field. The research at MPA on dynamic fracture is very advanced and, in my opinion, a prime area for collaboration with the US Navy.

1/17/85

Mathematics

NEW INRIA CENTER STUDIES NONLINEAR FILTERING

by Charles J. Holland. Dr. Holland is the Liaison Scientist for Applied Mathematics/Computational Science in Europe

and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until December 1985 from the Office of Naval Research, Arlington, Virginia, where he is the Deputy Division Director of the Mathematical Sciences Division.

The Sophia-Antipolos Center of France's Institut National de Recherche en Informatique et en Automatique (INRIA) opened in October 1983 to become the third center of this internationally regarded French government research organization. This article gives a brief overview of the organization of the center and then highlights important work on nonlinear filtering and smoothing. If these difficult problems can be solved, there will be valuable military and industrial applications in guidance, filtering, and control.

This INRIA center, near Nice, has the same mission as the other two--to conduct fundamental and applied research in computers and control. Dr. Pierre Bernhard, who works in differential games and control, heads the staff of about 50 at Sophia Antipolos (compared to the total INRIA staff of about 500). Approximately 80 percent of INRIA's funding comes from the French government, with the remaining 20 percent from industrial contracts. Research projects are expected to obtain some financial support from industry within a couple of years of their initiation--thus ensuring a connection with applications.

The research activities of the INRIA research centers can be divided into eight themes: scientific computing; control; image processing and robotics; software engineering; languages; computer systems (for example, operating systems, databases, compilers); man-machine interfaces (ergonomics); and new computer architectures. According to Bernhard, approximately 50 percent of the effort at Sophia-Antipolos can be classified as research in expert systems. This work includes a project in which control theorists are designing an expert system to help biologists devise realistic models of biological systems. The remaining 50 percent of the work can be classified as research in control and filtering and scientific computations in fluid dynamics.

The Sophia-Antipolos Center was created in a research park setting in an attempt to create a situation similar to that at Stanford or the Research Triangle in North Carolina. Other French research organizations have created branches there (among them the Centre National de la Recherche Scientifique),

and IBM already had a research center nearby. The first signs are very encouraging, although it is too early to determine the character of the final setup.

Nonlinear Filtering and Smoothing Research

Professor E. Pardoux, who is also a mathematics professor at the Université de Provence in Marseilles, heads a small group of researchers at Sophia-Antipolos investigating both theoretical questions and the development of numerical algorithms for nonlinear filtering and smoothing of diffusion processes. Filtering and smoothing problems arise in many industrial and military applications concerned with tracking, guidance, and control.

As is well known, a solution to the linear filtering problem was provided by the fundamental work of Kalman and Bucy. However, the nonlinear filtering and smoothing problems have been especially difficult--both in theoretical and numerical algorithm development.

The typical mathematical setup for these problems is as follows: There is a state process $x(t)$ which evolves according to an Ito-type stochastic differential equation

$$dx = f(x)dt + h(x)dw(t).$$

The process $x(t)$ itself is not observed; instead an observation process $y(t)$ is observed which evolves according to another Ito-stochastic differential equation $dy = g(x,y)dt + K(x)dw(t)$. (The Brownian motions w , w may not be independent.) At each time t , the filtering problem involves determining the conditional probability law of $x(t)$ given the past observations up to time t . The smoothing problem involves determining the conditional law of $x(t)$ given observation over a time interval $(0, s)$ with $0 < t < s$.

In contrast to the nonlinear filtering problem, the smoothing problem has received attention only recently--with Pardoux's work on this problem over the last few years being especially illuminating. In recent work (1980-82), Pardoux derived an expression for the unnormalized conditional law as the product of two functions, each of which satisfies a stochastic partial differential equation. In this formulation one partial differential equation evolves forward in time (this being a Zakai equation) and the other backward in time.

Now, using his recent work with U. Haussmann (University of British Columbia) on the time reversal of diffusion

processes, Pardoux has developed an alternative method which involves what he calls a backwards smoothing problem. This formulation leads to a backward Zakai equation and a forward adjoint stochastic partial differential equation. In addition to this second expression for the unnormalized conditional density, he obtains two other representations, thus leading to a total of four equivalent representations. In particular, one of these last representations generalizes a result of Wall-Willsky-Sandell for the linear case where the solution of the linear continuous time smoothing problem is given in terms of a forward and backward Kalman filter and the *a priori* law.

Dr. Francois leGland, in Pardoux's group at Sophia-Antipolos, is investigating an approach to the nonlinear filtering problem for Markov processes; the approach is based upon using Monte-Carlo techniques for the calculation of the conditional expectations as an alternative to numerically solving the Zakai equation (which is a stochastic partial differential equation). He has shown that the most direct implementation of the Monte-Carlo idea is unsatisfactory. The difficulty arises in that the integrals to be evaluated are of Laplace type involving terms of the form $\exp -F(\cdot)$. The significant contributions to the integral arises only for a "rare" number of paths in which $F(\cdot)$ attains its maximum--and these paths are not typically achieved in direct simulation. To overcome this difficulty, leGland proposes using the idea of importance sampling. This is a technique of variance reduction in Monte-Carlo methods based upon an optimal change of probability. In these methods, for every admissible probability measure, a new estimator is constructed whose variance may be evaluated; the optimal probability chosen is the one that minimizes this criterion. For application to these problems arising in filtering, leGland allows Girsanov-type changes of probability measures. The optimal change of probability measure is not found; instead a suboptimal one is constructed from applications of large-deviations theory. This approach has been tested by leGland on several problems. In all the preliminary ones tested it leads to much better estimates than direct sampling, but the new estimates are still far from the actual value in some cases.

Other researchers in Pardoux's group at Sophia-Antipolos are investigating other questions for special classes of nonlinear filtering problems. Dr. Jean Picard is investigating the

case of small observation noise. He has preliminary results which lead to error bounds for using the Extended Kalman Filter. Dr. Denis Talay is analyzing discretization schemes for stochastic differential equations. In practice, the actual pathwise solution of the stochastic differential equation is not the quantity of interest, but rather some functional of the path. He is attempting to develop approximation schemes which are more accurate for the quantity of interest rather than the solution itself. Finally, Catherine Savona, a student of Pardoux's at Marseilles, is working on filtering problems in which the state and observation dynamics are piecewise linear.

Conclusion

In a short period of time, the new INRIA Center at Sophia-Antipolos has established a reputation for excellent work in computers and control. In particular, Pardoux has built a small, energetic group of young researchers who are doing important and fundamental work in nonlinear filtering and smoothing. These problems are exceptionally difficult, but their solution--in terms of numerically computable algorithms--would have a high payoff for military and industrial applications in guidance, filtering, and control.

1/15/85

WORKSHOP ON INVERSE PROBLEMS HELD IN MONTPELLIER, FRANCE

by Charles J. Holland.

The general bases of physics describing many physical processes are well known--for example, the propagation of acoustic waves for sonar and electromagnetic waves for radar through the environment. These dynamical processes are typically described mathematically by differential equations. In any particular situation, the values of the coefficients entering the equations usually are not known but are of great importance. The process of attempting to determine these coefficients (and hence the existence and location of objects in the medium) is known as an inverse problem. Inverse problems arise in many areas important to the US Navy and to industry--ocean bottom and seismic modeling, radar target classification,

nondestructive evaluation, medical tomography, and nuclear magnetic resonance. Recent advances in computing power have created the opportunity for novel approaches to problems arising in these applications areas of increasing difficulty and realism.

The 13th Annual Workshop on Inverse Problems, held in Montpellier, France, from 27 November through 2 December 1984, reported recent activity in this area. The workshop was organized by Professor P.C. Sabatier (Université des Sciences et Techniques du Languedoc, Montpellier, France), who is one of the leading researchers in the field. This was primarily a European conference, with approximately 90 percent of the 70 participants from Europe; about 50 percent were from France. Lectures were given in both French and English. Proceedings will be published informally in a Cahiers Mathématiques de Montpellier; write to Sabatier for information about the proceedings.

Participants discussed not only the diverse engineering application areas mentioned above, but also inverse scattering problems in quantum mechanics and in so-called "inverse problems" in nonlinear evolution equations. While there was significant participation of these last two areas, I will concentrate on European activities related to geophysical applications.

At Montpellier, Sabatier leads a group of two mathematicians and a few geophysicists who are exploring novel approaches to inverse problems. In the standard approach, as described above, one attempts to give as a solution the best or most likely estimate of the unknown parameters which enter into the problem (e.g., in seismology, the location of layers and the sound speeds in the layers); but one is not usually concerned with the evaluation of the range of uncertainties. Unfortunately, these parameter estimates may not be robust with respect to changes in the data. Sabatier's alternative is to formulate a set of "well-posed" questions which depend continuously on the data. In many cases these questions involve the determination of bounds of functionals of the data. (For example, what is the maximum possible value of the functional consistent with the data?) By formulating these well-posed questions, Sabatier feels that this approach gives a view of the set of solutions which is similar to the "views" of the object in industrial design. For many of these well-posed questions, the answers can be found by solving linear programming problems. Sabatier and his colleagues

have applied this approach to several engineering problems, including a systematic study of a polymetallic mine by gravimetry, electric, and ferromagnetic prospecting. This is an interesting alternative approach to many problems which may yield the actual desired information in a robust manner.

Dr. V. Richard, (Société Nationale Elf Aquitaine) discussed a new approach being developed in France at Institut National de Recherche en Informatique et en Automatique, ELF, and other institutions, for solving the vertical seismic reflection problem. This problem occurs when one attempts to determine the layering structure in the Earth or the ocean bottom from reflection measurements of an explosive source. In this approach an initial guess of the unknown parameters is made, and the direct problem is solved numerically to generate synthetic data. These data are compared to the measured data by means of an appropriately chosen cost function, and a new guess for the parameter is chosen using the conjugate gradient method. The process is then repeated with this new guess. At the workshop, successful results of this procedure on sample problems were illustrated. It is clear that advances in computer power have made this approach more feasible than it would have been in the past. It is still too early to tell how this method will compete with existing methods--such as migration--in terms of cost and performance.

Dr. A. Roger (Faculté des Sciences et Techniques, St. Jerome-Marseilles) has been investigating a model one-dimensional problem in geophysics for recovery of the complex permittivity, assumed to be piecewise constant, in a borehole. This is an important problem in seismic exploration for recovering information about the structure of the Earth after a well has been drilled.

The determination of the complex permittivity of a stratified medium from measurements of an electromagnetic field is a technique currently used in optics and electromagnetics. In optics, the source is placed in the upper medium (air), and measurements of the reflected field for different angles of incidence may permit one to recover a permittivity profile.

In Roger's model setup, an emitting source and two receivers at different fixed levels below it move together in the borehole. Thanks to the simplicity of the model, Roger has been able to develop an algorithm which he has tested successfully on simulated data. He is planning to consider the extensions to

three-dimensional problems with cylindrical symmetry and to the case where the permittivity is not assumed piecewise constant. As he notes, his current approach cannot be applied to either of these new problems in a straightforward manner.

Summary

Advances in computing power are making feasible the development of novel approaches as well as applications to a wider class of inverse problems. In particular, the conference at Montpellier illustrated some interesting alternative approaches (the formulation of inverse problem as optimization problems) and applications (electromagnetics in seismology) being developed by French researchers. For a summary of other approaches, see the proceedings of the 1984 Cornell University Conference on Inverse Problems of Acoustics of Elastic Waves, sponsored by the Office of Naval Research, Arlington, Virginia (San Jose, F., et al., *Inverse Problems of Acoustic and Elastic Waves* [Philadelphia: SIAM, 1984]).

1/15/85

Mechanics

TRANSONIC UNSTEADY AERODYNAMICS AND ITS AEROELASTIC APPLICATIONS

by K. Isogai. Dr. Isogai is Head of the Aeroelasticity Section of the First Airframe Division of the National Aerospace Laboratory, Tokyo, Japan.

The specialists meeting of the Advisory Group for Aerospace Research and Development's 59th Meeting of the Structures and Materials Panel was held in Toulouse, France, from 3 through 5 September 1984. The topic of the meeting was transonic unsteady aerodynamics and its aeroelastic applications. The meeting was held at École Nationale Supérieure de l'Aéronautique et de l'Espace.

A total of 132 scientists attended the meeting. The scientific program was composed of 16 lectures; all papers were invited.

Session I

V.L. Peterson (National Aeronautics and Space Administration [NASA], Ames Research Center, US) discussed the status and prospects of computational fluid dynamics (CFD) and computer capabilities, especially from the standpoint of their aeroelastic applications. According to his estimates, in order to simulate unsteady flows including shock waves and the shock-induced flow separation around three-dimensional (3D) aeroelastic surfaces within 15 minutes of CPU time, one might need the computer capabilities of 65 mega-words memory and about 80 giga-flops of computing speed (flops: floating point operations per second).

H. Triebstein and R. Voss (German Aerospace Research Establishment, West Germany) presented the results of their extensive measurements of steady and unsteady aerodynamics for a two-dimensional (2D) rectangular wing with a NACA0012 and a supercritical MBB-A3 profile, which oscillate in pitch and heave. They stressed the importance of the shock-induced flow separation and the possible dynamic effects of perforated wind tunnel walls on the unsteady pressure measurement data.

W.J. Chyu and S.S. Davis presented the calculated results obtained by their Reynolds averaged Navier-Stokes code (2D) for an oscillating NACA64A010 airfoil and NLR7301 supercritical airfoil. These results were also compared with the experimental data. Their Navier-Stokes computation successfully reproduced the behavior of unsteady aerodynamic forces characterized by the strong shock-wave and turbulent boundary layer interactions. Another important finding was that the computed results with the full and thin-layer Navier-Stokes equations showed no significant difference in the magnitude of instantaneous surface pressures.

Session II

By using the 2D transonic small perturbation potential code EXTRAN2L, J.W. Edwards et al. (NASA Langley Research Center, US) made extensive calculations of unsteady pressures and airloads on airfoils performing pitching oscillation, with oscillating flap, and performing transient ramping motions. The calculated results were compared with the available experimental data also. The comparisons between the calculated and experimental results for a thick supercritical airfoil (NLR7301) are of particular interest since they clearly show the limitation of the small perturbation code for treating thick airfoil sections.

D.J. Salmond (Royal Aircraft Establishment [RAE], UK) described the detailed development of a method to solve the Euler equations to obtain steady and unsteady transonic aerodynamic forces on oscillating 3D wings. As far as I know, this is the first development of the unsteady 3D Euler code. Salmond's method is an extension of the implicit, finite-difference method used by Pulliam and Steger to solve the steady flow problem.

P. Girodroux-Lavigne and L.C. LeBalleur (National Aerospace Research Office [ONERA], France) described an interesting method for calculating attached or separated unsteady transonic flows over airfoils. The method, based on the viscous-inviscid interaction procedure, solves the unsteady small perturbation equation coupled with the defect integral equations of the boundary layer and the wake. The researchers successfully reproduced the self-induced flow oscillations caused by the shock wave and the shock-induced flow separation on the 18-percent thick circular-arc airfoil, which until then had been calculated only by a Navier-Stokes code. The method seems to have a great potential as an unsteady viscous transonic flow code to be applied to the aeroelastic problems, since it should be an order of magnitude faster than the Navier-Stokes code. M.J. Green et al. (British Aerospace, UK) proposed a semiempirical method for calculating unsteady transonic aerodynamic forces on wings for Mach numbers greater than unity. Their method is an extension of that originally proposed by Garner (RAE, UK). The method may provide an economical means of carrying out transonic flutter calculations at a time when the more accurate finite difference methods are costly for routine use.

Session III

M.J. McCroskey et al. (NASA Ames Research Center, US) first described the state of the art of the CFD capabilities and then discussed what sort of improvement should be made in algorithms and numerical techniques in order to solve the unsteady transonic viscous flows around a complex oscillating wing within a reasonable computation time. According to their estimate, the computation time for solving an aeroelastic problem of a 3D wing by using a Navier-Stokes code, which is estimated to take more than a week on a 250 mega-flops machine, can be reduced to 1 hour (on the same machine) if considerable improvement in the algorithms of the finite difference scheme could be attained.

Mulak et al. (ONERA, France) described an alternating direction

implicit procedure for solving the small disturbance transonic potential flow over highly swept wings. As the numerical examples, the steady and unsteady pressure distributions were calculated for a high-aspect-ratio transport wing and a fighter type low-aspect-ratio wing.

M.H.L. Hounjet et al. (National Aerospace Laboratory, The Netherlands) described an efficient hybrid method to solve the time-linearized full potential equation, which combines the advantages of finite difference and integral methods. The calculated unsteady aerodynamic pressures were composed with the experimental data obtained for the LANN wing (a high-aspect-ratio transport wing with supercritical airfoil sections). They also made the flutter calculations of a fighter-type configuration and found that the transonic airloads have a strong stabilizing effect on the flutter boundaries of this wing.

J.B. Malone et al. (Lockheed-Georgia Company, US) described their recent experiences with three state-of-the-art, finite-difference computer programs that have been developed for the prediction of unsteady transonic flows about airfoils and wing configurations: (1) the XTRAN3S code, a 3D unsteady small disturbance method developed by Borland et al.; (2) the SUNTANS code, a 2D unsteady full-potential method developed by Malone et al.; (3) the USIPWING code, a 3D unsteady full-potential method developed by Sanker et al. They also presented the numerical results obtained for several wings and airfoils and compared them with the experimental results.

Session IV

A. Laulent (Avions Marcel Dassault-Breguet Aviation, France) described a 3D fully conservative code which solves the transonic small perturbation equation by using an alternating direction implicit scheme. They applied their code to calculate unsteady pressure distributions on an oscillating NACA0012 30-degrees swept wing and predicted three kinds of shock motions which indeed were observed in the experiment on a 2D airfoil.

P. Goorjian et al. (NASA Ames Research Center, US) described the development and application of transonic small perturbation codes at Ames Research Center for computing 2D flow, using the code ATRAN2, and for computing 3D flow, using the code ATRAN3S. They also presented the calculated unsteady pressure data obtained for various 2D airfoils and 3D wings and compared them with the available experimental data. The effects of viscosity on both the unsteady aerodynamic forces and flutter

speeds of rectangular wing and swept wing were also discussed.

My paper described the development and applications of the unsteady transonic 3D full potential code developed at Japan's National Aerospace Laboratory. In addition to the calculated unsteady pressure data, the paper presented the results of various aeroelastic applications of the code, including the static and dynamic aeroelastic response calculations of a high-aspect-ratio transport wing.

Session V

Session V was devoted to round-table discussions; the theme was the present and future roles of CFD methods in transonic flutter clearance. Among the many comments of the panelists, the following are notable:

1. An efficient method for calculating 3D unsteady aerodynamic forces which utilizes 2D CFD codes with some 3D corrections should be developed so that the CFD codes can be extensively used for aeroelastic calculations in the aircraft industries.

2. Liaison is necessary between CFD code developers and structural dynamicists.

3. Wind-tunnel flutter tests must be done very carefully because of the possible effects of factors such as wind-tunnel wall interference and sonic resonance.

4. It may take considerable time before CFD codes are extensively used in industry because aircraft industries are conservative in this respect. (It is relatively difficult for aircraft industries to introduce Cray-type supercomputers.)

5. CFD code developers in government research laboratories should have contact with structural dynamicists in the industries.

Conclusion

The papers presented at this meeting clearly show the state of the art of the currently available computational methods for calculating unsteady transonic aerodynamic forces on 2D airfoils and 3D wings. Although the methods based on the potential flow assumptions, both 2D and 3D codes, are certainly approaching their maturity, further validation of the codes, especially 3D codes, seems to be necessary. Aeroelastic applications of 3D potential codes have just started (only three of 16 papers described the aeroelastic applications), and therefore the research in this direction should be intensified. It is also my impression, from the aeroelastic-application viewpoint, that the

computation of the unsteady viscous transonic flows will become increasingly important, and therefore research on the efficient numerical techniques also will be (or should be) accelerated.

11/19/84

Physics

ADVANCED SOLID-STATE DEVICE RESEARCH AT SIEMENS: THYRISTORS AND DIODE LASERS

by P. Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

Siemens A.G. is doing pioneering work in two areas: thyristor research and high-power diode lasers. The first effort is supervised by Dr. H. Runge and Dr. P. Kolbesen; the second is done in the group concerned with opto-electronic devices, under the general leadership of Dr. K. Mettler.

Siemens A.G. is one of the oldest and largest international enterprises in electrical and electronic engineering products, ranging from power systems through communication and other electronics areas to giant computers. It employs, worldwide, 300,000 people, and its annual expenditures are estimated to be DM40 billion (about \$14 billion).

Its basic-research and early-phase-development central laboratories are now in Neuperlach, southeast of Munich, on a striking campus that is about 6 years old. This facility is staffed by 1900 people. (An additional 500 work at a smaller central lab in Erlangen. There are, in addition, several special-purpose labs that do R&D in areas that received the "go ahead" from the central laboratories.)

The central laboratories' research is conducted in three divisions: Micro-electronics, Process Engineering, and Information Technology. The Microelectronics Division is doing the work described in this article. The points that merit special attention are the technical breakthroughs. In regard to thyristors, the researchers have achieved spectacularly high voltage, current, and power values, and have pushed the

switching time to an unusually short value. In the diode-laser work, the scientists have achieved unexpectedly high electric power to light efficiency values and have produced new designs (index guided wave guides) enabling efficient operation at longer wavelengths.

Thyristors

A thyristor, sometimes called a controlled rectifier, is a solid-state version of the thyatron. Earlier the term "four layer transistor" was used for thyristors, since the device consists of four variously doped layers in the order n-p-n-p. Many ways of connection can be set up, achieving various effects, but the one most frequently used, to be discussed below, is the reversed blocking triode connection, also called simply a "silicon-controlled rectifier" (SCR). In this case, the outer n-zone is used as the anode (also called the collector), the inner p and n layers form bases, with the p zone connected to the gate (sometimes called "the" base), and the outer n layer serves as a cathode ("emitter"). The diagrammatic representation and an idealized cross-section view are shown in Figure 1. If the anode is biased negatively with respect to the cathode, then the two outer p-n junctions become polarized in the blocking direction, and the behavior of the system is the same as for a blocked diode. If the bias is positive against the cathode, the inner p-n junction acts as blocking layer--if the voltage remains below a certain trigger value which is determined by the positive gate current. If this critical value is exceeded, the injected charge carriers destroy the inner blocking layer, and the thyristor behaves as a diode operated in the conducting direction. In this case (i.e., after a trigger pulse has acted), the anode current is determined almost entirely by the characteristics of the external circuit in series with the anode-cathode path, provided that this current exceeds a small "holding current" value. Once the high conductivity mode is achieved, the gate current has no further control over the anode current. Turning off the anode current is quite a difficult problem: one must reduce the anode-to-cathode voltage (to the extent that the anode current falls below the holding current), or in fact reverse the polarity of the anode voltage. The operation of the thyristor may be also pictured by looking at it as two coupled transistors, where the collector current of one serves as the base current for the other.

Figure 2 shows the concentration of carriers in the inner n-layer as a function of distance from the junction (in a three-layer transistor we have a monotonic decrease), and Figure 3 is a schematic representation of the current-voltage characteristic.

The remarkable features of SCR are the extreme speeds of switching and the enormous ratio of controlled to controlling current. Thyristors in many variations, sizes, and load ranges have been devised during the less than 10 years that have passed since they were discovered, and principal uses include regulation, power control, controlled rectification, and power conversion. It appears that fast switching mechanisms for very high power devices (such as for high-power pulsed laser sources, electromagnetic microwave generators and charged particle beam accelerators), which play important roles in US Navy and other Department of Defense research, may take good advantage of advanced thyristors.

At Siemens two major lines of thyristor research are pursued. One concentrates on large-size bipolar operation mode (BIP) elements, the other on metal oxide solid-state (MOS) mode controlled gate operation units.

BIP Work. The primary motivation for the work of the BIP group comes from the effort to produce reliable and high-performance systems that convert high-voltage, alternating-current power into high-voltage, direct-current power and vice versa. The need for this procedure arises because, at the very high voltages and powers now commonly used, the capacitive loss of AC high-power lines can be very large for long-distance transmission. In fact, for underwater power cables such losses will become intolerable even for distances as short as 5 km. Moreover, converting AC to DC and, after transmission, reconvert it into AC by means of thyristor banks, allows for an easy change of frequency (say, from 60 to 50 Hz or vice versa).

The BIP device developed at Siemens for this AC-DC-AC conversion has the shape of a 5- to 10-inch-diameter disk, with a total thickness of about 1 inch. The doped silicon is molded onto a molybdenum base (which serves as the anode), and the cathode and gate connections on the top of the disk are formed by a central "circle" and a concentric ring-like silver contact, respectively. The latest samples take 5-kV, 4-kA currents and operate at an average power of 8 kW. Their rise time (switching jump) is a few microseconds.

For power conversion, many of the disk units are packed into tall

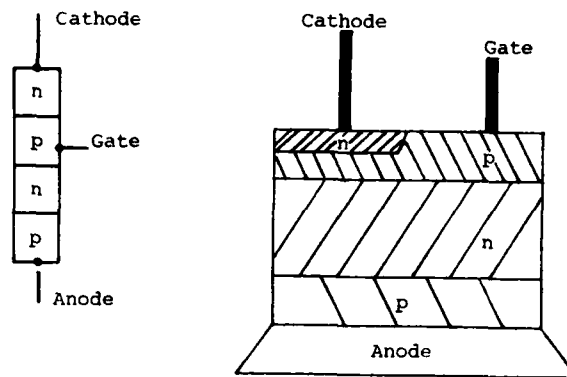


Figure 1. The SCR.

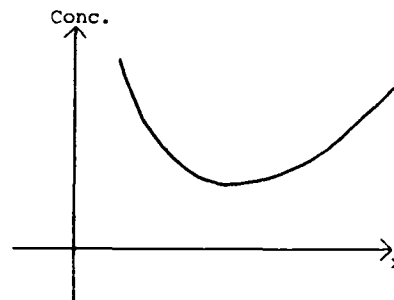


Figure 2. Concentration of carriers.

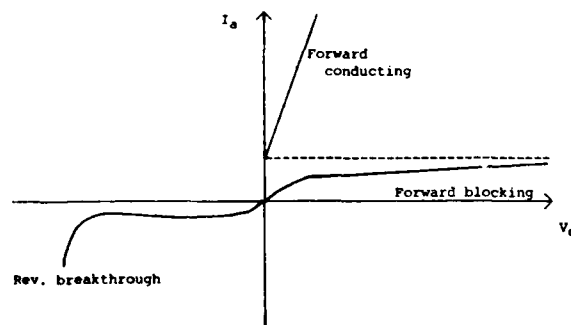


Figure 3. Current-voltage characteristic.

"towers." To make them fit for withstanding the enormous ponderomotive forces, they are pressed together by special membrane springs providing 4 tons of pressure. Substantial water cooling is arranged for. One experimental power system setup has a package of 1200 thyristors (one at each end of the transmission line). The line is 500-km long and carries 1-GW power.

Plans at this time are to develop thyristors suitable to carry 10 kV (this will reduce the number of units needed in the package). One will not be able to go higher because the intrinsic conductivity of Si sets a limit. The current cannot be increased beyond the present value, because this would necessitate the use of Si disks with larger diameter; but they cannot be made large and still maintain crystal quality. Work is in progress to achieve better arcing protection. Finally, more reliable switching control and faster (less than fractions of a nanosecond) switching times are a goal of high priority.

MOS Work. The primary concern of the MOS group is to improve the switching mechanism and, more specifically, to develop reliable switch-off capabilities. One of their concerns is to develop stable "gate turn-off" thyristors (GTOs). In the standard switch-off solutions that work via the "dV/dt firing" mode (see my introductory comments on thyristors), one encounters unpredictable effects that arise from the displacement current due to the voltage change. The Siemens group (as well as others) succeeded in short-circuiting the disturbing displacement current by arranging a GTO system with a "finger structured" sequence of emitter regions, as sketched in Figure 4. If approximately -15 V are applied at the gate, then the hole current is sucked off. The holes have a complicated movement and, because of the requirement of electric neutrality, induce a change in the number of electrons. The recombination heat is enormous. Most of it develops very shortly after the gate is turned on with the negative potential and when the current still has high values because of the finiteness of the recombination time. Apart from the fact that cooling may present a serious problem, these GTO devices have also the disadvantage that 20 to 30 percent of the load current passes through the gate, which conflicts with the requirement to have a small amount of power in the control circuit.

The Siemens group aims to solve these problems by replacing the standard gate with a MOS gate construction. They have demonstrated that in such devices only 1/100 of the power used in standard GTOs is needed to trigger the gate.

The Siemens group gladly admits that other researchers--such as RCA and General Electric in the US--use similar methods, including conductivity-modulated field effect transistor or isolated gate transistor applications for gates, or even the combination of external field emission transistors with a thyristor. But the best gates presently

G: Gate
C: Cathode

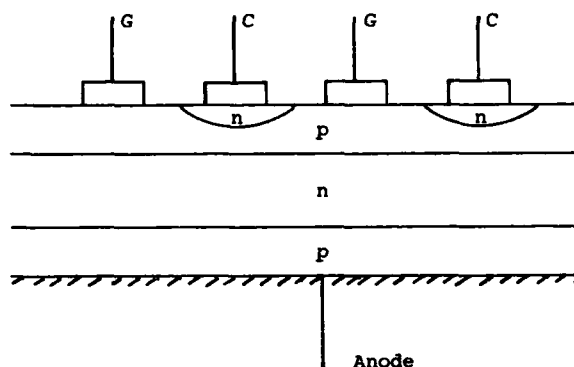


Figure 4. Emitter region structuring.

available allow "only" for a 1-A gate to 1000-A load current ratio, and the Siemens MOS thyristor people are confident that they will beat the competition by doing things faster and also by extending the maximal power range. Furthermore, they are considering the construction of thyristors that employ in a combined arrangement bipolar gates (for forward conduction control) and MOS gates (for switching off).

Yet another line of their research concerns novel methods of triggering thyristors. It is known that much faster jump-times can be obtained if, instead of employing a voltage at the gate, the firing is done by triggering the thyristor with light. If infrared photons penetrate into the middle p-layer (which behaves as a space-charge zone), electron-hole pairs are created. The electrons are attracted away by the anode and pass easily through the thin n-layer above it. The holes, in turn, wander to the top of the inner p-layer, hence the base receives a positive bias and the thyristor fires. It is known that Soviet researchers have successfully employed direct sideways illumination of the p-base layer and presumably achieved near-picosecond switching times. The Siemens group is experimenting with shining the light (from a fiber) directly on the top n-layer and creating charge carriers in the entire volume. Currently they use small, low-power thyristors to be triggered by light which then, via their output voltage, trigger the large power-thyristors in the usual manner. Eventually they hope to integrate the small and large thyristors in one solid-state device.

They have found that up to 25-m distances they can use a simple light emitting diode to send a pulse through the fiber to the thyristor. However, for larger distances, good coupling required the use of a laser diode source operating at 950 nm.

It should be noted that recent reports from the Schenectady R&D Center of General Electric in the US indicate that they also achieved light triggering of a set of 100 small pilot thyristors, which then activated a stack of power thyristors. The novelty is that the light was obtained simply from a new kind of high-intensity caesium-mercury flashlamp. It remains to be seen which approach will be more successful.

Diode Lasers

Development of unusual or high-quality solid-state diode lasers has a well-documented history at Siemens. Their first success was the construction of an oxide stripe GaAs laser operating at 880 nm, with a remarkable total efficiency of 30 percent. It is now commercially available, and is used either by itself as a sender chip or it is integrated into a complete module for incorporation in a printed sender circuit.

More recent efforts concentrated on devising a laser that could use the 1.3- μ m window in the fiber-attenuation spectrum and be suitable for small-dispersion operation. This task is solved by using material combinations, such as In Ga As P, on an InP substrate. Because of the extreme thinness of the strips (0.1 μ m), liquid phase epitaxy cannot successfully be used for fabrication, and therefore the Siemens researchers developed efficient metallo-organic gas epitaxy procedures. Using this technique, they put together several, up to 40, structures on one chip, and recently obtained strong coherent output with about 1-W power in CW operation, and a record total power efficiency greater than 36 percent. The entire chip has only a 400- by 500- μ m size. Possible applications include free-space optical communication, spectroscopy, pumping for YAG lasers, and, to connect with the first part of this article, triggering of thyristors.

The group is now experimenting with tying together several such lasers and exciting them individually in succession. In this way, beam steering can be achieved. Possible uses are for active star couplers, optical multichannel switches, and optical phase arrays. They are also experimenting with using this technique to get mode selection, leading to a very narrow line width. This would

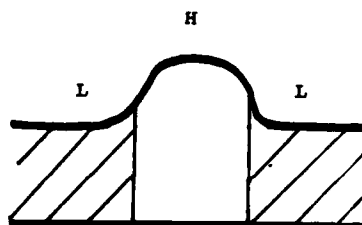


Figure 5. Ridge wave-guide.

lead to improved local oscillators for heterodyne modulation.

Finally, a bold attempt is now under way to conquer the opportunities offered by the 1.8- μ m fiber window. At this wavelength or a longer one, a completely new method will have to be used. The Siemens group is experimenting with index-guided (wave-guide) operation laser devices (as opposed to gain-guided systems). In this approach the losses are considerably reduced so that a lower driving current is needed, which in turn reduces the heat loss. The technical problem is to construct such a device with a single epitaxy operation. The suggested solution is to use a metal-clad ridge wave-guide. The basic idea of this new Siemens patent is sketched in Figure 5. The surface area H has a high conductivity contact, while that of the area L is low. The shaded areas function as wave-guide "walls." It should be noted that the current goes mainly in the central region, which will increase the light intensity.

The researchers have not yet decided whether, in the final optical sender device, the modulation will take place in the laser or in a section following it.

12/7/84

LASER RESEARCH AT GARCHING: SOME RECENT ACHIEVEMENTS AND PLANS

by Paul Roman.

The renowned Max-Planck-Institut für Quantenoptik is a center for research on lasers, laser-system development, and laser applications. Already highly acclaimed for its research accomplishments, the institute continues to increase the capabilities of its lasers and to explore important research

applications that use frontier laser technology. This article reports current and planned research that is of interest to the US Navy R&D community.

Located in Garching, a suburb of Munich, the institute is, in its present organizational form, relatively young--less than 4 years old. But its roots go back to the days when many of its current staff performed their research under the aegis of that large and venerable organization, the Max-Planck-Institut für Plasmaphysik (IPP). About a decade ago, IPP decided that systematic efforts toward practical achievement of inertial confinement fusion using lasers must be dropped (so as to concentrate resources better on magnetic confinement work). Therefore, a group of IPP researchers under the leadership of Dr. S. Witkowski joined forces with part of a research group of Professor H. Walther at the Universität München and formed a "Projektgruppe" with governmental support for selected special topics. Instead of fusion research, laser development and a broad field of laser applications became the focus. Since, by West German law, special research groups cannot be maintained for more than 5 years, the group eventually was taken over by the Max-Planck-Gesellschaft and reorganized as the Institut für Quantenoptik. It is led by a Direktorium, consisting of Professor K.L. Kompa, Walther, and Witkowski; each year they rotate the post of Executive Director (currently Witkowski). The Direktorium also has an external scientific officer, Professor M.O. Scully (University of New Mexico).

Currently the institute has over 100 employees, with about 35 permanent and 40 guest PhD scientists. The labs and offices are squeezed into very modest facilities provided as a service by the IPP, but a new, independent building is under construction and will be occupied in 1985 or 1986.

In conformity with the particular expertise and orientation of the Direktorium members, the work of the institute is concentrated on the major areas of laser plasmas (Witkowski), laser chemistry (Kompa), laser spectroscopy (Walther), and theoretical quantum optics (Scully). It appears that there is a common denominator to these activities--namely, laser and laser-system development. This article highlights a few items, and does not necessarily follow this division of the institute into sections.

Laser-Plasma Research and Associated Laser Development

Laser-plasma work, of course, had its original motivation in the research

oriented toward laser-initiated inertial fusion. However, since highly ionized plasmas with extreme densities and temperatures, as in stellar interiors, cannot be produced in the lab efficiently by means other than high-energy laser beams, the general study of the physical principles underlying both the formation and behavior of such laser plasmas is surely a high-priority research area for its own sake. It is not surprising that Witkowski's group also receives outside support from the European Atomic Energy Community, Euratom (via a contract with IPP).

Since generation of interesting plasmas requires a variety of very high output lasers with different characteristics, the group was and is deeply involved in laser development work.

There is a choice of possible laser systems to use. The giant CO₂ lasers, such as those developed at the US Los Alamos National Laboratory, operate at 10.6 μm , and this wavelength is too long for current experimentation on implosion phenomena. Nd/glass lasers (with an ideal $\lambda = 1.06 \mu\text{m}$) have been used in the past, but the Garching group found this technology too expensive for sustained work. Furthermore, since the dielectric constant of the lasing medium increases with intensity, the beam will eventually split up and cannot be well focused at extreme intensities. Moreover, these lasers have a low repetition rate. Thus, the final choice of the Witkowski group--motivated also by the fact that other very high energy lasers (such as Nd:Yag) have been developed elsewhere--was the development of an extremely powerful iodine atom gas laser. (For background on the basic operational principles of I-vapor lasers, see ESN 39-3:102-103 [1985].) This highly acclaimed laser system, called Asterix III, operates currently at 1.315 μm (a good compromise). A 1-mJ pulse is generated in the mode-locked oscillator. When this is passed through four amplifiers (which have increasing diameters and, as the oscillator itself, are pumped by Xe flashlamps), a final pulse of 0.25-ns duration and 300-J total energy is obtained. An average power of 1 TW was observed. A good feel for the enormity of the system may also be gained when one considers that the 8-m-long, 20-cm-diameter final amplifier is operated under 1000 Torr argon gas pressure (with 6-Torr pressure for the C₃F₇I gas).

Plans for the foreseeable future call for increasing the energy output to 2 kJ. This will be achieved by adding a fifth amplifier. The new system, to be set up in the forthcoming new building, will be called Asterix IV. The new

amplifier will consist of eight modules. The first module, more than 2-m long, has been fabricated and is undergoing extensive testing. (An experimental condenser bank, with 96-kJ energy output at 40 kV, is supplying the pumping power.)

The final design and installation of an image-relaying system is a special problem that must be solved before the entire Asterix IV system is set up. As is well known, in chains of laser amplifiers one is bound to encounter interference maxima and minima which arise because of the diffraction of the highly coherent light on apertures or obstacles in the system. For very high energy lasers these local intensity increases may easily destroy various laser system components. With the help of suitable image-relaying techniques one can achieve a homogeneous intensity distribution at critical points in the system, such as windows, mirrors, and lenses. The technique is based on imaging of a homogeneously illuminated aperture by a Kepler telescope, with simultaneous beam expansion by the telescope. However, the iodine laser operates in the saturation regime--i.e., we must face nonlinearities that affect the properties of image relaying. These problems were explored at Garching last year, both theoretically and experimentally, and the results will be used when Asterix IV is finally put together. Two of the novel image-relaying elements already have been fabricated.

Another interesting development concerns the generation of harmonics. The second, third, and fourth harmonics already have been successfully employed for plasma experiments; recently the fifth and sixth harmonics (263 and 219 nm, respectively) have been produced with high efficiency, so that the system now can operate from the infrared to the ultraviolet. The conversion to 5ω was achieved by forming the sum-frequency of the second and third harmonic in a KDP crystal. The sixth harmonic was produced by doubling the frequency of the third harmonic ($\lambda = 438$ nm) in a potassium-pentaborat (KPB) crystal. But because of the low nonlinear coefficient of KPB, the intensity of the third harmonic first had to be increased tenfold by a telescope. Current work attempts to improve the conversion rates for the case of the forthcoming extremely high intensities, where the rate tends to fall off because of reduced phase matching.

Work is also proceeding on the eventual replacement of the current initial stages of Asterix. To this end, an experimental iodine laser amplification chain (called EVA) is now being

constructed and tested. It consists of an oscillator, a pulse cutting system, a preamplifier V_0 , and two subsequent amplifiers V_1 and V_2 . Between V_0 and V_1 an image relaying system is inserted. Pulse shortening, in general, is a serious concern of the system developers, and various experimental studies are in progress. Somewhat surprising results regarding the changes of the spatial profile have been found.

The following list suggests recent trends in the plasma research of Witkowski's group.

1. In experiments with the $\lambda = 0.44$ μm third harmonic it was found that even at the intensities of 10^{15} W/cm² the reflection losses were higher than 50 percent. It became important, therefore, to study the scattering mechanism, by means of measuring the spectrum and the angle distribution of the scattered laser light. The investigators concluded that ion sound waves, excited by the laser plasma flowing from the target into the vacuum, play an important role.

2. To study the expected increased acceleration of film (membrane) targets for shorter wavelength laser light, the $\lambda = 0.44$ μm radiation was used in experiments on 2.8- μm plastic film targets. (For other studies, films of various materials in the thickness range 0.1 to 100 μm have been routinely used.) With an ingenious technique using shadow imaging, it was found that even though the pressure increases with decreasing wavelength, the requirement of homogeneous acceleration imposes very stringent criteria on the beam quality.

3. Several experiments study various aspects of inverse bremsstrahlung, resonance absorption, stimulated Brillouin backscattering and $3/2$ ω scattering. These experiments, together with current or planned work in hydrodynamical and energy transport phenomena in plasmas, as well as high time- and spatial-resolution diagnostic techniques, reveal a wealth of fundamental information. Heavy ion stopping in plasmas is another research line, which ultimately may have relevance for ion beam induced fission.

Laser Chemistry

Kompa's laser chemistry group concentrates on the initiation and control of physico-chemical and purely chemical reactions and processes, as well as on the specific activation of molecules by novel mechanisms, using laser technology. Lasers furnish new possibilities in these areas by a variety of mechanisms, such as short processes or multiphoton excitations.

The group concerns itself both with effects and phenomena that just cannot be done without lasers and also with areas where lasers do the job more efficiently. The following list, which suggests some of the group's concerns, does not do justice to the diversity of the projects under way:

- Multi-photon dissociation of molecules, induced by pulsed infrared laser light.
- Isotope separation (with same source), concentrating on C^{13} , I^{123} , S^{32} .
- Laser study of catalytic processes associated with surfaces as well as surface modification by lasers.
- Laser-induced collisions and the spectroscopy of transition states. Latest examples are Na-H_2 and Xe-Xe collisions, using visible and ultraviolet (UV) light, respectively.
- Polymerization and a variety of practical chemistry processes induced or controlled by lasers.

Laser Development in the Laser Chemistry Group

I was particularly interested in the laser development work done in Kompa's research unit.

Last year, one of these projects was to develop a high-pressure (20 at) CO_2 laser which can be operated either in a narrow band mode or in a 3 cm^{-1} broad band mode. (This laser was used in spectroscopic experiments regarding infrared multiphoton absorption, and it established that this absorption depends on bandwidth.) Currently work is done on the construction of a multi-line CO_2 laser.

In the area of improving beam quality and tunability of UV laser sources, work is in progress to exploit nonlinear optical phase conjugation for beam correction in excimer lasers. Earlier work on stimulated anti-Stokes-Raman shift in dye lasers is also continuing.

Further laser development work is planned to achieve new laser transitions in the UV and VUV regime with nitrogen molecule devices, which are pumped by a combination of one- and two-photon excitation mechanisms.

Finally, work is continuing on a 7-year-old joint project with the West German government's research institute in Jülich; the project is aimed at constructing and improving $76\text{-}\mu\text{m}$ wavelength, high-power lasers. A fixed frequency version is now routinely used in experiments for uranium isotope separation. Current work concentrates on improving a tunable version. This, like its fixed frequency predecessor, uses Raman scattering in para-hydrogen of

laser light obtained from a CO_2 laser. However, because of insufficient primary peak power, the conversion cannot be effected by direct application of stimulated Raman scattering. Instead, a parametric 4-photon mixing in the Raman medium is employed. The light of a high-power CO_2 -TEA laser and of a low power high-pressure CO_2 laser are synchronously and collinearly coupled into a cooled multi-reflex cell filled with gaseous para-hydrogen. After each of the 49 transits, the pumping beam is refocused. The large number of technical problems and details has been successfully solved and the system now operates with a 10-Hz repetition rate at $16\text{ }\mu\text{m}$, with 30-ns pulses carrying 10-mJ energy. The tunability is 615 to 630 cm^{-1} , and the bandwidth is between 0.05 and 0.15 cm^{-1} .

Optical Bistability

The third major group at Garching is directed by Walther and is a classic center not only of laser spectroscopy but also of several bold attempts to branch out into new areas where lasers play a central role in a manner similar to that in more conventional spectroscopics applications. To illustrate the spirit of this research group, I conclude this kaleidoscopic report on selected activities at Garching by reporting on a "side-show"--amusing research done primarily by Mr. A. Dorsel, a student of Professor P. Meystre of the theoretical laser physics group and working in the adjacent lab of Munich University, whose director is Walther (by joint appointment). The work consists of the demonstration of optical bistability in a device that uses only light pressure. A parallel plate Fabry-Perot interferometer is constructed from a fixed mirror and a very light (60 mg), suspended, dielectrically coated quartz plate. The light in the resonator exerts a pressure on this suspended mirror which leads to a change of the *physical* length of the resonator, proportional to the intensity of the light. Using laser intensities as low as a few milliwatts, one can observe a typical hysteresis loop in the plot of outgoing versus incoming power. The acoustic and seismic perturbations can be greatly reduced by increasing the laser intensity. This self-stabilization of the mirror can be easily explained via the combined effects of light pressure force and gravitational force, and damping. Currently other interferometer geometries are pursued in which the light pressure effect is symmetric and hence more efficient. With laser energy of a few hundred milliwatts the mirror can be stabilized to less than 15 angstroms.

Naturally, because of its slowness and large volume, this bistability device cannot be used for optical computers. However, since the system behaves as an exceptionally sensitive transducer between mechanical and optical signals, it could be well used in the sensing or measurement of extremely small translations. Surface effect experiments, purely optical microphones, and supersensitive seismometers are possible areas of application.

12/6/84

Space Sciences

LONG-TERM SPACE SCIENCE PROGRAM FOR ESA

by Norman F. Ness. Dr. Ness is the Liaison Scientist for Space Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until June 1985 from Goddard Space Flight Center, NASA, where he is Chief, Laboratory for Extraterrestrial Physics.

Europeans have contributed very significantly to the advancement of space science. This has been accomplished in national programs, bilateral projects with the US and to a much lesser degree with the USSR, and the multilateral European Space Agency (ESA) program. In December 1984, ESA published an extensive report summarizing its proposed long-term program in space sciences. Dr. Johan Bleeker (Utrecht, The Netherlands) was chairman of the survey committee, initially formed in September 1983, which completed its findings in July 1984.

ESA has planned an aggressive and very challenging program based upon four cornerstone missions by spacecraft. Two of these are in the area of solar system, planetary and solar terrestrial physics sciences, while the other two are in astronomy. Of these four cornerstones, three would cost about \$400 million, since they represent major spacecraft projects. The survey committee has strongly recommended that the program based on these four essential cornerstones, along with further medium- and small-size projects, be approved for the next two decades. This requires a

moderate but continuing increase in the budget for solar system sciences and astronomy during the next 7 years. Persuasive arguments are presented to justify this activity, and it will be very interesting to observe the evolution of this decidedly ambitious program.

The report, entitled *Space Science--Horizon 2000*, covers in detail the main thrusts of the 20-year program which were identified. The document is intended to provide a foundation for the review and elaboration of future levels of resources in the "mandatory" scientific program of ESA. The report includes in-depth analyses of the various scientific areas as well as complete analyses of the various proposed mission concepts.

The survey committee was organized into four principal scientific areas: solar and heliospheric physics was chaired sequentially by P. Delache from Nice, France, and P. Hoyng from Utrecht; space plasma physics was chaired by G. Haerendel from Munich, West Germany; planetary science was chaired by S.J. Bauer from Graz, Austria; and astronomy was overviewed by A. Fabian from Cambridge, UK, E.P.J. Van den Heuvel from Amsterdam, The Netherlands, and I.W. Roxburgh from London, UK. The survey committee to which these topical teams reported consisted of seven members of the ESA Solar System Advisory Committee along with seven other scientific representatives from various organizations, such as the European Science Foundation; CERN, the European Organization for Nuclear Research; the European Southern Observatories; and the International Astronomical Union.

The ESA 20-year program is founded on four major cornerstones in the four disciplinary areas mentioned and assumes a moderate increase in funding. Its purpose is to offer a quantum jump of significant scientific research opportunities for the European community. Space science has recently celebrated its silver anniversary (1957-82) and has been transformed from basically an exploratory activity to one of a basic element in fundamental scientific research. The new frontier of space presented significant technological challenges which led to the development of new devices, materials, and--most importantly from a humanistic viewpoint--positive contributions in the area of worldwide communication facilities and the ability to comprehensively study and monitor the physical environment of our planet.

Because space science and technology have now matured, the complexity

and lifetime of typical missions planned far exceed those of earlier investigations. As a result, the costs of both development and operations are much larger; hence there is a substantially reduced frequency of launches and, correspondingly, opportunities for scientific investigations. Nonetheless, ESA hopes to be able to retain sufficient flexibility in its program to allow simple and ingenious missions for unexplored areas and changing emphasis.

From an industrial perspective, scientific contracts constitute "a technological pull" providing specific requirements in areas such as advanced optics, cryogenic systems, high-accuracy attitude control and analysis systems, high-precision mechanisms, extremely high data communication channel capacities, and large computational facilities. ESA considers it to be in the best interests of European scientists that the European program be coordinated closely with those of other agencies outside Europe and particularly with the US National Aeronautics and Space Administration (NASA). This opens additional possibilities for European scientists and avoids wasteful duplication so as to increase the scientific return with respect to the total investments made.

The principal criteria for the development of an independent European long-term program are: a high standard of scientific research, a suitable mix of large and small projects, flexibility and versatility to match the changing frontier of scientific studies, the provision for continuity of efforts to both scientific institutes and industry, a high technological content, adherence to realistic budget limits, and maintenance of a proper balance between truly European and cooperative projects with other agencies.

One of the greatest intellectual adventures of modern time is the exploration of the universe from our solar system to the most remote distances. Dramatic changes in our views about the universe, our solar system, and Earth have occurred in the past two decades as a direct result of scientific space exploration. (An analogy might be drawn with the change in perspective which resulted from the development by Galileo of a new technological device, the telescope.) The Horizon 2000 study indicates that the ESA is now in a position to conduct systematic investigation *in situ* of the solar system and, remotely, the universe in those parts of the electromagnetic spectrum which have been previously blocked or obscured by the Earth's atmosphere and its environment--

namely in the areas of radio, infrared, ultraviolet, and x-rays and gamma rays. These new opportunities and windows were opened by the technological development of the rocket and microelectronics. The following paragraphs briefly summarize the major projects in the Horizon 2000 study.

Solar and Heliospheric Physics

Mission concepts and programmatic elements in solar and heliospheric physics begin with the all-important Ulysses mission, formerly called the International Solar Polar Mission, which is to be launched in 1986. This spacecraft will use a gravity assist from the planet Jupiter to raise to 80 degrees its heliocentric orbital plane of inclination with respect to the ecliptic. This will place the spacecraft close to the poles of the Sun. Unfortunately, the companion US spacecraft in the mission was unilaterally dropped by the US 2 years ago in a budget crunch.

The rapid development of the new field of helioseismology has stimulated much study; and the Solar Heliospheric Observatory (or SOHO) mission, proposed for a launch in the early 1990s, is directed to providing those necessary measurements for these investigations. The spacecraft would be placed into heliocentric orbit about the L_1 Lagrangian point and would be part of the International Solar Terrestrial Physics program which NASA, ESA, and Japan have been studying.

ESA is also proposing to launch free-flying spacecraft in Earth orbit in order to provide ultra-high spatial resolution of the Sun at sub-arc-second precision with imaging and spectrometry simultaneously in many wavebands. The Synoptic Array Program is a constellation of four spacecraft in heliocentric orbit at the L_1 Libration point and at 90, 180, and 270 degrees heliocentric longitude increments with respect to that. This would provide synoptic coverage and global measurements for magnetic field modeling, the study of global structures, stereo viewing of coronal structures, and directivity observations of particles and solar flares.

Another project is the Heliosynchronous Out of the Ecliptic Mission (HOEM), which is to place a satellite at the solar distance of about 31 solar radii (0.15 astronomical units) so as to be quasisynchronous with the solar rotation period. Scientific areas for investigation from this mission include evolution of solar structures and the solar wind from a near vantage point, *in-situ* sampling of a wide latitude range in a shortened period of time,

frequent coverage of the polar regions of the Sun, and stereoscopic viewing.

Finally, ESA proposed a solar probe with a perihelion distance of only a few solar radii in order to penetrate to within the solar corona down to regions where much of the acceleration of the solar wind occurs. This would result as well in an opportunity for studying the gravity field of the Sun and continued testing of general relativity theory. Both HOEM and the solar probe would be launched at the turn of the century.

Space Plasma Physics

The second cornerstone of the Horizon 2000 program addresses the discipline of space plasma physics. The most recently launched AMPTE mission (ESN 38-12:625-627 [1984]) and the forthcoming GIOTTO and Ulysses missions will be the next milestones in this program area from the European scene. A multiple spacecraft mission, CLUSTER, represents a basic plasma physics research mission which could also become part of the International Solar Terrestrial Physics program previously mentioned. It should be noted that, as is often the case, it is quite feasible to include appropriate instrumentation for this disciplinary area on those spacecraft in solar and heliospheric missions.

Planetary Science

The third area of scientific interest is that of the planets. European scientists are deeply involved in the forthcoming Galileo mission to Jupiter, scheduled for launch in May 1986. This spacecraft will place a probe into the atmosphere of Jupiter and a spacecraft in orbit about the planet. Due to radiation hazard and damage considerations, however, the spacecraft perijove, initially at the orbital distance of Io (6 Jovian radii) will be raised to 15 Jovian radii, and gravitational assists from the satellite Ganymede will appropriately modify the line of apsides so as to optimally trace out the near planet-magnetic-tail region of the magnetosphere.

More advanced missions under consideration include the Cassini project to place a probe into the atmosphere of Titan and to place a spacecraft in orbit about Saturn. This mission is similar in concept to the Galileo mission, and indeed the US recently considered using the spare Galileo spacecraft for such a role but rejected it on the basis of cost and scientific return. Another comprehensive mission being studied is a Comet Rendezvous Asteroid Flyby (CRAF), which would provide multiple encounters with several asteroids as well as the

very new and exciting rendezvous with a comet. Both CRAF and Cassini are missions presently under study jointly with the US, but it has not been decided whether ESA will participate in both of these missions.

Additional new mission concepts presently under investigation include the Mars orbiter mission known as Kepler, providing for a scientific study of the surface, atmosphere and plasma environment of that planet; a lunar orbiter mission with primary scientific study of surface composition and magnetic fields; and multiple Venus orbiters for investigation of the atmosphere, its dynamics, and surface properties.

Since ESA has not yet pursued the exploration of bodies in the solar system other than Earth, except for the GIOTTO intercept mission to comet Halley in 1986, scientists of the ESA community are enthusiastic in their endorsement of these missions for the European community at large. More than 450 scientists with interests and capabilities in planetary research were recently identified in a survey conducted by the European Science Foundation.

Space Astronomy

The last cornerstone area of the future program of ESA is space astronomy, which includes high energy astrophysics, ultraviolet optical astronomy, infrared and submillimeter astronomy, radio astronomy, and gravity and relativity. The most advanced field of space research is probably that of high-energy astrophysics. First- and second-generation missions have already been flown by US and European scientists. A number of member states in ESA have planned specific missions tailored to the more parochial interests and capabilities of their own scientific communities. West Germany, in collaboration with the US, is developing an all-sky, soft x-ray survey, the ROSAT mission, to be launched in 1987. Italy has planned a hard x-ray spectrophotometric mission, called SAX, while France is planning a gamma-ray imaging mission, known as SIGMA.

ESA believes it is now timely to consider developing the third generation of observatory-class spacecraft in which there will be an improvement, by a factor of 10 to 100, in sensitivity, spatial and temporal resolution, and number of objects studied. European scientists are participating in the Gamma Ray Observatory (GRO) to be launched in 1988 and the soft x-ray mission (AXAF--Advanced X-Ray Astronomical Facility) of the US. It is not their intent to compete with the GRO mission as they believe that a complementary mission to

AXAF deserves high priority. This particular mission (XMM--X-Ray Mapping Mission) would provide spectroscopic studies of x-rays with a high throughput observatory. This is also one of the four cornerstone missions of the ESA plan.

In the area of ultraviolet and optical astronomy, the development has closely paralleled that in high-energy astrophysics. Since the Space Telescope (ST) mission will not provide instruments sensitive in the 900- to 1200-angstrom region, a follow-up to the International Ultraviolet Explorer mission would permit study of the morphology of molecular hydrogen and deuterium throughout the universe. Since Europe possesses the required expertise to make a major contribution to such an observatory, this is a particularly attractive mission.

It is expected that ST will dominate astronomical research for at least the next decade in the visual portion of the electromagnetic spectrum. Since Europe has secured access to at least 15 percent of available observing time by its contribution to ST, substantial future results and discoveries can be expected from the ST mission. ESA has planned an astrometric mission known as HIPPARCOS. Measurements from this spacecraft will improve the accuracy of distance-scale astrometric parameters by at least two orders of magnitude and will provide the largest systematic catalogue of stellar positions and parallaxes for dramatically improving the baseline of the stellar distance scale.

Finally, it should be noted that following the ST and HIPPARCOS successes may be associated advances in ground-based astronomy using optical interferometry. Clearly the long-term future of optical space astronomy is in the direction of interferometry, and ground-based experience and results will be critically important in determining the future thrusts.

Beginning with balloon-borne and aircraft-supported telescopes, infrared astronomy has blossomed in the past 15 years to the most recent flight of the highly successful spacecraft IRAS, the Infrared Astronomical Satellite. This was a unique trilateral venture among The Netherlands, the UK, and the US. IRAS's spectacular results have appeared recently in the public and scientific literature. Data from this spacecraft are now available for studies by scientists who were not directly involved. This first photometric sky survey has provided an overwhelming number of fascinating results; future spectroscopic investigation of the objects discovered with IRAS is obviously a prime target.

Initial steps in this direction will be accomplished with the German Infrared Laboratory spacecraft, which will be flown on the shuttle in the late 1980s. The Spacelab II mission, hopefully to be launched in 1986, will contain a small liquid-helium-cooled telescope for a study of the galactic region at low spatial resolution.

The most exciting ESA development post-IRAS is the Infrared Space Observatory, which will be built and launched by ESA in the early 1990s. This will follow up on earlier measurements with a wide range of infrared instrumentation.

The last major unexplored portion of the electromagnetic spectrum is the submillimeter wavelength band. The NASA launch in 1987 of the Cosmic Background Explorer will provide a map of the large-scale distribution of the cosmic background radiation at submillimeter wavelength. Present European programs are directed toward appropriate technology for submillimeter antennas which will provide the timely support of a submillimeter heterodyne spectroscopy spacecraft. This is the last of ESA's four cornerstone missions and clearly represents a major step forward for Europe to take the lead in studies of stellar and planetary system formation, origin and evolution of galaxies, and small-scale granularity of cosmic background radiation.

Recent development of practical aperture-synthesis techniques has allowed the construction of radio interferometers in both Europe and the US. Indeed, transcontinental interferometric measurements are now providing maps of various radio sources with angular resolution limited only by the terrestrial diameter baseline. It is anticipated that a space-borne radio telescope in elliptical orbit could be linked to both European and American ground-based array networks and thereby provide images of unprecedented angular resolution. Thus ESA will have available technological and scientific expertise in ground-based millimeter radio astronomy; ESA will be able to use this competence as the basis for an evolution including space-borne elements which will be feasible as the 21st century begins.

Conclusion

From a budgetary viewpoint, the future program outlined above will require an increase of approximately 50 percent over the present funding level of \$130 million per year. ESA is optimistic that this new level can be established by 1991. From an administrative-scientific viewpoint, this amount would fund all

major projects presently required, and would allow a number of medium- or small-size projects. As it turns out, industry has "independently" arrived at the same figure on the basis of considerations regarding the frequency of mission opportunities appropriate for the industrial and technological community. Such an increase in the science budget would accompany the anticipated increase in ESA's budget for large initiatives in the area of space transportation systems and the manned space station.

At the ESA Council of Ministers meeting held in Rome on 30 and 31 January, an extremely important vote on the Horizon 2000 program was taken. Approval was granted for the mandatory space science program budget to increase by 5-percent real growth each year for the next 5 years. Although less than the requested 7 percent for 7 years, this does represent a major boost to ESA space sciences and should see the initiation of a number of exciting projects, including SOHO and CLUSTER in the solar terrestrial physics area. This move, coupled with a decision to join in with the US space station effort, indicates that Europe is beginning to be much more adventurous in its program-matics and planning.

Copies of the Horizon 2000 report (ESA Special Publication SP-1070, December 1984) can be obtained from the European Space Agency, 8-10 Rue Mario-Nikis, 75738 Paris 15, France.

1/11/85

News and Notes

THE INTERNATIONAL ADHESION CONFERENCE 1984

The Plastics and Rubber Institute sponsored the International Adhesion Conference 1984 from 12 through 14 September 1984 at the University of Nottingham, England. The 35 oral presentations and the 19 poster presentations represented research from the UK, the US, West Germany, France, Australia, Canada, Sweden, Israel, Ireland, and East Germany.

This conference reflects the widespread interest in adhesive bonding

today with applications ranging from aircraft to shoes. The papers involved both basic research and applications and were divided into seven areas of interest: chemistry of adhesives, surface chemistry, bonding of plastics, stress analysis, fracture, durability, and applications. Highlights of some of the oral presentations are given below; many of the papers will be published in the *International Journal of Adhesion and Adhesives*.

The conference indicated that the improvement and application of adhesive bonding requires interdisciplinary approaches. Areas of active research include bond durability/adherend preparation, adhesive formulation, and fracture mechanics.

Chemistry of Adhesives

Shaw and Kinloch (UK Ministry of Defence) showed that the strength of a bismaleimide resin can be improved by the addition of a carboxyl-terminated butadiene-acrylonitrile rubber. L.L. Lee (Xerox) reviewed the trends in new adhesive materials; he concluded that water-borne, hot-melt, and radiation-curable adhesives are the materials of the future.

Surface Chemistry

R.A. Pike (United Technologies) received considerable attention when he reported that his preliminary results suggested that bonds with smooth adherend surfaces produced by an aluminum chelate and alkoxide reaction could provide similar bond strengths to those with microrough surfaces. Such surfaces generally are thought to be necessary for good adhesion properties (P.J. Hine et al., University of Bath). J.A. Bishopp (Ciba-Geigy) showed that complete wetting of the adherend by the adhesive is necessary for high bond strength, while H.P. Schreiber et al. (École Polytechnique) indicated that bond durability in a humid environment is degraded when the moisture has direct contact with the adhesive.

Durability

D.J. Arrowsmith and coworkers (University of Aston and Admiralty Underwater Weapons Establishment) presented a very interesting preliminary report. It dealt with a new aluminum pretreatment (anodization in sulfuric acid followed by etching in phosphonic acid) which appears to provide excellent bond durability--similar to that for aluminum anodized in phosphoric acid or etched in a Forest Products Laboratory solution and then treated with hydration inhibitors, such as nitrilotris methylene phosphonic

acid (G.D. Davis and coworkers, Martin Marietta).

C.W. Matz (Messerschmitt-Bölkow-Blohm Transport Aircraft) noted that short-time test methods must be carefully analyzed to assure relevancy to long-term, real-life situations. A. Stevenson (Malaysian Rubber Producers' Research Association) investigated the degradation of rubber/metal bonds in seawater, while H. Dodiuk et al. (Israeli Ministry of Defense) reported on the reduction of bond strength due to water absorption by the adhesive during storage and the restoration of strength, in some cases, by drying the polymer prior to bonding.

Guy D. Davis
1/14/85

SWEDISH GOVERNMENT, INDUSTRY JOIN FOR GaAs DEVELOPMENT

A total of about SKr50 million (\$6 million) will be spent in Sweden on developing integrated circuits of gallium arsenide and on building production facilities for such equipment over the next 3 years. The government will defray SKr20 million of this cost, while the remainder will be invested by the Ericsson group company Rifa AB, which is responsible for the project.

The goal of the project is to build up production resources for gallium arsenide integrated circuits and design capabilities to handle orders for fully tested components.

In 1984, Rifa announced development of tiny high-speed gallium arsenide transistors that are three to five times faster than conventional silicon transistors. The gallium arsenide transistors are mounted in sets of four on chips measuring only 0.35x0.49 mm.

Larry E. Shaffer
1/23/85

FAST ASSEMBLY ROBOT DEVELOPED BY SWEDISH FIRM

An assembly system incorporating a newly developed robot, intended for light- and medium-volume assembly work, has been introduced by ASEA Robotics, a member of Sweden's ASEA electronics and electrical engineering group. According

to the manufacturer, the robot, called IRB 1000, is faster than any other assembly robot now available on the international market. Its acceleration is said to be more than 50 percent higher than that of conventional arm-type robots.

The design of the IRB 1000 is based on the pendulum concept with a hanging robot arm; it has six electrically powered motions. The Multigrip 1000, a new steplessly adjustable gripper system developed for the robot, has eight different two- or three-finger grippers which can be used simultaneously.

With the system, production material can be supplied automatically for up to 8 hours. ASEA's Robot Vision System can also be integrated in the IRB robot to enable the flexible supply of material and to perform inspection tasks.

For more on robotics at ASEA, see ESN 37-8:301-303 (1983).

Larry E. Shaffer
1/23/85

UK FORMS NEW INSTITUTE OF METALS

A new force for professional engineering in the UK was created on 18 January 1985. The Institution of Metallurgists and The Metals Society merged to form the Institute of Metals (see ESN 38-10:561 [1984]). It is possible that this new institute could become the fifth force in the UK's engineering profession, joining the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Chemical Engineers, and the Institution of Electrical Engineers as the leaders of the engineering profession.

Sir Hugh Ford (past president of the Institution of Mechanical Engineers and the old Institution of Metals before it became The Metals Society in 1974) will be the first president of the new Institute of Metals. The long-range goal of this new institute will be to attract membership from fields other than just metals (ceramics, polymers, and adhesives). The only materials excluded in the institute's charter are natural and synthetic fibers used in textiles.

Kenneth D. Challenger
1/23/85

PSYCHOLOGICAL ASPECTS OF PHYSICAL ILLNESS

A special issue of the *International Review of Applied Psychology* (Vol 33,

No. 4, October 1984) is devoted entirely to research on the psychological aspects of serious physical illness. Topics include: the social and emotional consequences of head injury and stroke; coping with hemophilia; affective disorders in cancer patients; stress in hospitalized patients; the psychology of recovery from surgery; the psychology of cancer chemotherapy; and professional and public attitudes and behavior in relation to cancer. One paper comes from the US; all the rest is UK work.

Richard E. Snow
1/8/85

PHILOSOPHERS OF SCIENCE CONSIDER COGNITIVE SCIENCE

Cognitive science is a newly defined field, designed to span the confluence of cognitive psychology, artificial intelligence, psycholinguistics, logic, epistemology, and other disciplines, aimed at understanding human and artificial intelligence, cognition, and knowledge organization and use. Some individual philosophers of mind and of science have also contributed to this confluence (see, notably, Dennett, 1981).

Now philosophers of science are turning in numbers to critical analyses of the nature and foundations of this new science. Two distinguished European journals are now beginning to devote regular space to issues in cognitive science; one is *Synthese*, the other is *Conceptus*. Cognitive science articles will be handled for *Synthese* by Dr. B. Richards, School of Epistemics, University of Edinburgh, 2 Buccleuch Place, Edinburgh EH8 9LW, Scotland, UK. Articles for *Conceptus* may be addressed to Dr. Otto Neumaier, Institute for Philosophy, University of Salzburg, A-5020 Salzburg, Austria. See also the important collection of papers on this and related topics edited by Neumaier (1984).

References

- Dennett, D.C., *Brainstorms: Philosophical Essays on Mind and Psychology* (Cambridge, MA: MIT Press, 1981).
Neumaier, O., ed., *Mind, Language and Society* (Vienna: Verband der Wissenschaftlichen Gesellschaften Österreichs, 1984).

Richard E. Snow
1/8/85

EVALUATION OF GOVERNMENT MEASURES TO STIMULATE INNOVATION

The Organization for Economic Cooperation and Development has issued a report (OECD, 1984) based on a workshop aimed at examining the ways and means of evaluating policies and measures taken by member governments to stimulate innovation in business and industry for economic growth. Of special interest are government policies designed to influence development, marketing, and exporting of new technologies.

The report should be read carefully by both government officials and evaluation researchers alike, for it provides a review of what was thought to be known about evaluation a decade ago; there are both productive and counterproductive recommendations included.

The report concluded that: evaluation is important and should be integrated in innovation policies; evaluation is difficult; the methodology of evaluation is still in its infancy; evaluation is relevant only if its results are taken into account to remedy the deficiencies which it reveals; available methods include monitoring methods to collect and analyze data systematically, audit methods to diagnose problematic situations, and experimental methods to test well-defined changes in policy; the tools to be used include data collection surveys, and analytical procedures based on economic and statistical models. Then follows a review of: the responsibilities for carrying out evaluations; implementation rules; the presentation of conclusions; resources required; necessary steps to improve the conditions for evaluation; and criteria for successful evaluations.

It is a pity that the report was apparently written only by science and industry policy makers, and economists, only for science and industry policy makers, and economists; nothing of the conclusions of the evaluation-research literature over the past decade is referenced or heeded. It is recommended that this report be read by interested parties, but only in conjunction with such general modern references on evaluation as Cronbach (1982); Cronbach, Ambron, Dornbusch, Hess, Hornick, Phillips, Walker, and Weiner (1980), and such case studies as may be associated with reports about the modern development of small industry in such countries as Denmark, Greece, and the Netherlands (see Knudsen, 1984; Papayannides, 1984; Van Seumeren, 1984).

References

- Cronbach, L.J., *Designing Evaluations of Educational and Social Programs* (San Francisco: Jossey-Bass, 1983).

Cronbach, L.J., S.R. Ambron, S.M. Dornbusch, R.D. Hess, R.C. Hornik, D.C. Phillips, D.F. Walker, and S.S. Weiner, *Toward Reform of Program Evaluation* (San Francisco: Jossey-Bass, 1980).

Knudsen, M., "In Denmark, Small Means Successful," *Europe*, No. 12, 11-12 (1984).

Organization for Economic Cooperation and Development, *Report on the Workshop on the Evaluation of the Effectiveness of Government Measures for the Stimulation of Innovation*, OECD 24.215 (Pams, 1984).

Papayannides, A.D., "Small Firms Are Breaking Through in Greece," *Europe*, No. 12, 10-11 (1984).

Van Seumeren, H., "How Young Entrepreneurs Make Out in Holland," *Europe*, No. 12, 12 (1984).

Richard E. Snow
1/8/85

ONRL SPONSORS ROBUST-CONTROL SESSIONS AT MTNS-85

The US Office of Naval Research, London (ONRL), has helped to organize and is sponsoring two special sessions on robust control at the Seventh International Symposium on the Mathematical Theory of Networks and Systems (MTNS-85). The symposium will be held from 10 through 14 June 1985 in Stockholm, Sweden. ONRL can nominate two registration-free participants for this conference. For consideration, please write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

A central problem in feedback control is the design of systems which can operate effectively under the presence of disturbances, modeling errors, and other uncertainties. Recently, the mathematics of interpolation and norm approximation, once considered solely in the domain of pure mathematics, has been finding applications in feedback control synthesis (see ESN 38-12:620-621 [1984]). The two ONRL-sponsored sessions will report on European, American, and Canadian research in this area.

The purpose of MTNS-85 is to bring together research engineers and mathematicians to discuss mathematical problems of a systems-theoretical nature arising in applications of current interest—including, for example, optimal control, filtering, circuits and systems modeling, and control-theoretical aspects of artificial intelligence.

Charles J. Holland
1/28/85

COLLOQUIUM ON MEDICAL OCEANOGRAPHY

The Centre d'Études et de Recherches de Biologie et d'Océanographie Médicale (CERBOM) of Nice is organizing the Eighth International Colloquium on Medical Oceanography. The colloquium will be held in Nice at the Centre Universitaire Méditerranéen from 9 to 12 October 1985.

This 4-day meeting will address the following topics: pollution and marine ecotoxicology, techniques of sewage sanitation and their consequences on the marine environment, physiopathology of diving, and oceanography and economy.

Each session is to include reports (20 minutes) and short communications (10 minutes) followed by discussions. A few scientific movies are also being planned and will be shown at selected times throughout the colloquium. All presentations will be simultaneously translated into French and English.

For registration forms and more information, contact: Colloquium Secretariat, CERBOM, 1 Avenue Jean Lorrain, 06300 Nice, France.

Thomas C. Rossell
1/15/85

CONFERENCE ON BIOTHERMODYNAMICS

The second International Conference on Biothermodynamics will be held from 8 to 13 September 1985 at Schloss Seggau near Leibnitz, Austria. The conference will be held under the auspices of the Interunion Commission on Biothermodynamics, the Austrian Academy of Sciences, and the Austrian Biochemical Society.

The program of this conference will consist of overview lectures, short oral communications, poster sessions, and round-table discussions. Contributions are invited from all areas of biothermodynamics, especially the following: biological membranes and model systems; nucleic acids and their interactions with proteins; mass-action phenomena, including ligand binding and aggregation; nonequilibrium systems; and methodological and theoretical advances.

The official language for the conference is English. Accommodation (full board) for about 180 participants will be provided at the conference site. Additional rooms, if needed, will be reserved in the hotels of nearby Leibnitz.

A meeting excursion and receptions are planned for all participants and their registered accompanying guests. Schloss Seggau is situated in the hilly, wine-growing area south of Graz, the

capital of Styria. It offers optimal opportunities for cultural and recreational activities.

For more information and registration forms, contact: P. Laggner, Steyrergasse 17, A-8010 Graz, Austria.

Thomas C. Rozzell
1/15/85

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

The Role of DNA in Brain Activity, Naples, Italy, 27-29 May 1985.

First European Conference for Research on Learning and Instruction, Leuven, Belgium, 10-13 June 1985.

Seventh International Symposium on the Mathematical Theory of Networks and Systems, Stockholm, Sweden, 10-14 June 1985.

Influence of Electric and Electromagnetic Fields on Biological Structures Symposium, Bologna, Italy, 24-29 June 1985.

Technological Application of Bilayers, Vesicles, and Langmuir-Blodgett Films, Denerja, Spain, 26-30 November 1985.

EUROPEAN VISITORS TO THE US SPONSORED BY ONR, LONDON

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CDT Arnold Böhrer Rekruterings on Selectiecentrum Sectie Psychologisch Onderzoek Kazerne Klein Kasteeltje 9de Linielaan 1000 Brussels Belgium	Military Personnel Psychology	NAVPERSRANDCEN Univ. of Minn. ONRHQ (Aug.-Oct. 85)	Richard E. Snow

SCIENCE NEWSBRIEFS FOR JANUARY AND FEBRUARY

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during January and February. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

<u>Science Newsbrief Number</u>	<u>Title</u>
3-1-85	Ion-Interaction Workshop To Be Held in Athens, by Thomas C. Rozzell.
3-2-85	UK Plans Cut in Research Jobs, by LCDR Rich Kelley.
3-3-85	Bioelectromagnetics Mini-Symposium To Be Held in Bologna, by Thomas C. Rozzell.
3-4-85	West Germans Produce Shape-Welded Components, by Kenneth D. Challenger.
3-5-85	ONRL Sponsors Robust-Control Sessions at MTNS-85, by C.J. Holland
3-6-85	Low-Temperature Microscopy Meeting Set for April in UK, by Thomas C. Rozzell

JANUARY MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during January. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

<u>MASB Number</u>	<u>Title</u>
1-85	Subsurface Portable Range for Acoustic Tracking (SPRAT)
2-85	Anti-Roll Systems for Modern Ships
3-85	Marconi 360° Surveillance/Area Defence Sonar System Improved
4-85	Bofors Optics Technology Man-Portable Night Vision Binoculars
5-85	Oceanographic Instruments From a UK Company
6-85	Real-Time Reconnaissance RPV Successfully Flight Tested by British Aerospace
7-85	Korvite--High Strength, Flexible Non-metallic Cable Material
8-85	Chemical Energy System Steam Generator
9-85	Oceanographic Sensor Chain and Winch From UK Company
10-85	Moire Pattern for Ship and Aircraft Positioning
11-85	Tentative Calender of 1985 NATO AGARD Panel Meetings

ONRL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONR, London.

- C-9-84 *The 20th International Symposium on Applied Military Psychology*, by Richard E. Snow. The symposium contained presentations on selection research with individual and group instruments, classification and job analysis, personnel systems and organization of psychological services, adjustment to military life and stress, organizational diagnosis and intervention, evaluation of new programs, and new emphases in large-scale research programs for the future.
- R-12-84 *French Plans for Fifth Generation Computer Systems*, by J.F. Blackburn. Since the October 1981 announcement of Japan's Fifth Generation Project, the French scientific and industrial communities have shown an increased interest in artificial intelligence languages, expert systems, man-computer interaction, novel computer structures, and knowledge-based computer systems. This report describes the French effort and includes a survey of the various French initiatives in hardware and software technologies aimed toward fifth generation computer systems and applications. These separate projects are the National Projects, the Joint Research Projects, the Centre National de Recherche Scientifique Cooperative Research Groups, and the Thematic Research Program.
- R-13-84 *The EEC's Information Technology Program--An Update*, by J.F. Blackburn. The primary goal of the European Strategic Program for Research and Development in Information Technology (ESPRIT) is to make the countries of the European Economic Community competitive in the world market for information technology. This report examines the five areas of the ESPRIT program for 1985: advanced microelectronics, software technology, advanced information processing, office systems, and computer-integrated manufacturing.
- C-1-85 *Third European Congress on Biotechnology*, by Claire E. Zomzely-Neurath. The Third European Congress on Biotechnology was held in Munich, West Germany, from 10 through 14 September 1984. This report examines trends in biotechnology suggested by the congress as well as the congress papers on thermophilic microorganisms, biosurfactants, immobilized cells and enzymes, applied genetics, food and feed bioprocesses, and fine chemicals and pharmaceuticals--bioprocesses and down-stream processing.

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